Forensic Cooperation *

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The objectives of this Academy include, among other things, encouragement in the study and practice of the Forensic Sciences. It is unique in that it brings together many (potentially all) disciplines of science and jurisprudence. This cooperation and free exchange of ideas and information between these scientists and lawyers is helpful in reaching factual conclusions from investigations whether they are civil or criminal in nature.

The meetings and publications of the Academy are an essential part of this program and will continue to be so as long as we approach the problem with this concept in mind. All disciplines represented in the membership of the Academy must participate in the meeting programs so that we do not become a group of independent sections. Many of us belong to associations in our own field of specialization and need not duplicate those organizations here. We can and should benefit through exchange of ideas with members from other branches of science and law. It is essential that members of the various sections meet and discuss their mutual problems but they should not do this to the exclusion of general or joint section meetings. We can always learn something from those who handle other phases of the investigations than we do.

A realization of our own capabilities and limitations is another important factor and we should know when to call for help from experts in other specialties. How many times

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has a pathologist, perhaps not too interested in forensic work, stated that not more than one shot could have been fired since he found only one wound. Then the firearms examiner comes up with parts of two bullets among the lead particles turned over to him; or the firearms examiner may make some categorical statement about the number of shots or the distance of a gun muzzle from the target based on the appearance of the wound or even on a description which is not too accurate. A good autopsy may correct this sort of information and these hasty conclusions. Then there is the attorney who is not familiar with makes, models and nomenclature of firearms and bases his defense on inaccurate information. In one case this involved the question of whether or not the particular type of ammunition could have been fired in a rifle or revolver. There is considerable difference between a thirty-two Winchester Special, a rifle cartridge, and a thirty-two-twenty or Winchester Center Fire, which is designed for both rifles and revolvers. Many other cases could be cited from all phases of investigations involving many scientific technicalities. The testimony of many experts has not been heard because of legal mishandling and more has been less effective than it should have been because the expert was not familiar with the legal aspects of the evidence and his testimony.

These situations could be helped or eliminated entirely if the individuals involved would seek the assistance of colleagues who are familiar or expert in other fields. Here education and instruction of individuals working in or closely associated with forensic investigations is important. While a major portion of our educational program should be aimed at providing formal academic instruction at college level and above we can still indoctrinate the people who will be conducting the investigations and are first at the scene, with the need for expert help. They can also be told of the capabilities and limitations of the scientific processes involved. How many times have you talked with someone about a case only to have them remark, "I didn't know you could do that sort of thing", and then describe a situation where he did not seek assistance because he did not know it was available?

If we become too restrictive in our thinking or in our associations the Academy will wither on the vine. We could even reach a situation similar to one described by my grandmother, referring to the Back Bay Boston area, where it was alleged the Cabots spoke only with the Lodges and the Lodges spoke only with God. When this happens organizations progress in ever diminishing circles with inevitable results. There are, perhaps, too few Gods among us.

As an example of a situation where cooperation was obtained through former contacts, I would like to describe the investigation of a fire at a nursing home in which seventy one persons died.

On February 17, 1957 the Katie Jane Nursing Home at Warrenton, Missouri was destroyed by fire. The fire occurred on a Sunday afternoon in a building approximately ninety feet square, three stories tall housing one hundred and forty nine patients. Many of these patients were bed-ridden and all were aged. Sunday visitors further complicated the situation.

The building, constructed between 1893 and 1903, was part of the Central Wesleyan College which was closed in 1943. The nursing home had taken over the buildings several years before the fire and remodeled them for dormitory purposes. The outer construction was brick but the interior was frame with wooden floors and much improvised wiring and heating facilities. Asphalt tile covering the floors also proved to be quite inflammable.

Warrenton, Missouri is the county seat of Warren County, a town of some 1500 people about 60 miles West of St. Louis. Fire fighting equipment of this small town was not able to control the rapidly spreading fire and departments from surrounding towns could not arrive in time to help. The fire was discovered at about 2:40 p. m. and reportedly spread throughout the entire building in about ten minutes.

City, County and State Highway Patrol officers were notified and began arriving at the scene within minutes after the fire was reported. The local unit of the Missouri National Guard was called out later to assist in spectator and traffic control as well as to guard the ruins during the night. This unit was a Military Police Company, which was sta-

tioned at Warrenton, and was an ideal unit for this type of duty.

Cooperation between agencies reporting to the fire was excellent and one early development was the establishment of an information center in an adjoining building under the supervision of a Highway Patrol sergeant. This office collected information and checked records to determine the number and names of individuals housed in the burning building. It also served as a center for collecting information about the location of persons who had escaped the flames. This task was complicated by the presence of visitors and the fact that some families either visiting or arriving at the home found their relatives and took them home without notifying the nursing home staff or other authorities. Many of the records pertaining to the patients in the building were destroyed. A complete listing was obtained before midnight and many families of survivors and missing persons had been contacted by that time.

Emergency equipment, including portable light plants, public address systems and heavy construction equipment were obtained and installed. Radio communications, particularly the Highway Patrol and Sheriff's radio net assisted greatly in locating equipment and in passing on information about available equipment and assistance which was standing by in several localities.

Realizing that there would be an identification problem, the laboratory and identification bureau of the Highway Patrol were notified. On recommendation of the laboratory and identification bureau no attempt was made to recover bodies pending the arrival of personnel from these departments. Additional collecting equipment in the form of crash bags and so on was arranged for at this time.

A temporary morgue was set up in a nearby vacant building and one body which was found just outside the burning building was removed to this building.

Upon the arrival of the identification and laboratory personnel and an inspection of the scene, a conference was held with the Coroner, fire fighting personnel and the local and state police agencies. Some ten bodies found around the periphery of the ruins were removed to the morgue after

which a halt was called until morning. The ruins were too hot to enter and fire weakened walls were a hazard to workers entering what was left of the building. The search was organized to commence again at daylight and the details were planned.

Heavy construction equipment, such as draglines and bulldozers were used to pull out the damaged walls early in the morning so that there would be no danger to the searchers in the ruins. Cranes were used to lift off heavy beams so that the debris could be thoroughly searched.

The search was organized to proceed through the area in a systematic manner and a technician was assigned to supervise the collection and labeling of any remains. A chart was maintained showing the location of each body or part of body as well as personal effects recovered. Each location was assigned a number which was placed on a tag attached to a crash bag with the remains and an evidence bag with associated material. These numbers and information were later incorporated in the descriptive sheet. The entire scene was gone through shovel full by shovel full and all pertinent material collected and marked for identification.

Services of a pathologist were obtained and each body or part of body was examined for medical and pathological data. This information was recorded on a simple data sheet which was prepared and printed by offset printing process the evening of the fire. The associated evidence, such as clothing, jewelry, prosthetic devices, and so on was placed in evidence sacks and marked with numbers corresponding to that of the body near which it was found. The bodies were then treated with preservatives since embalming was impossible in most cases.

By the middle of the afternoon of February 19th the search for bodies was completed and the entire fire scene had been searched. Bodies or portions of bodies from 67 individuals were recovered. Teams compiling records listed 149 persons housed in the burned building and accounted for 78 persons known to have escaped and survived. This left 71 remaining in the fire and indicated that four persons were completely consumed in the flames. This is understandable from the view of the ruins.

Comparison of information from the examination of the bodies and their locations with information compiled by the records section established tentative identification in most cases. Identification by attendants of associated items, such as clothing, jewelry, glasses and so on was, in many instances, more reliable than that of relatives who might not have seen the patients for a matter of months or even years. Since the medical records were destroyed in the fire, medical histories had to be recompiled from relatives. The final tally showed that 64 of the 67 bodies were at least tentatively identified. Forty six of these were accepted by relatives for burial and the remainder were buried in a mass funeral.

This record of recovery and identification of bodies from a complete fire could not have been accomplished without the cooperation of all agencies involved including the city, county and state officials. Credit must be given to the officials with primary jurisdiction, particularly the county coroner, for realization that assistance from the pathologist, laboratory technicians and identification personnel was needed. By obtaining this assistance early and following a definite plan for searching the ruins all available information and physical evidence was obtained and fully as important the details of the location was recorded. At the same time careful collection and tabulation of information available from records, nursing home employees, and relatives was important in the final matching of the data.

Volunteer assistance and heavy equipment was of inestimable value in this case. All too often, however, well meaning but unorganized assistance may so scatter and mix the material at the scene that further identification is almost impossible. In this instance the decision to wait until daylight, while watering down and cooling the ruins, permitted the organization of a co-ordinated search, recovery and recording procedure in addition to being a safety factor. Coroners and embalmers from neighboring counties and funeral homes were very cooperative and in several instances extremely helpful in recovering bodies from the debris. Using laboratory technicians to supervise, the shovel crews helped in the recognition of material to be collected. Not many of the volunteer diggers were familiar with the appearance of burned

bodies or parts of bodies or with the other items that might be of value as evidence for the identification.

There have been other cases where early realization that expert or trained personnel were needed has helped clear up investigations. In other cases, "too little and too late," the assistance has not been as effective as it might have been. There are still other cases where no assistance is sought and many sources of information are destroyed or ignored.

This case points up the fact that cooperation in these forensic fields can be had even in areas where there is no formal medicolegal system. Admittedly the coverage would be better and perhaps the co-ordination more effective if the organization was thoroughly set up before hand. We should not lessen our efforts toward a goal of adequate statutes to permit the use of modern scientific methods in our legal and investigative functions. This is not an argument for or against any medicolegal or coroners system but does point up the fact that we do not necessarily have to fold our hands and become utterly helpless in the face of inadequate legislation.

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The Fifth Freedom *

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Perhaps it was those factors which most greatly affect human behavior that led President Franklin D. Roosevelt to announce the Four Freedoms on January 6, 1941.

On that day, when part of the world raged in war and the rest apprehensively waited for it to spread, in his "State of the Union" message to Congress, the President defined what he considered to be the most important social and political objectives of the people of the United States. He called these factors "freedoms," and listed them to be:

(1) Freedom of speech and expression.

(2) Freedom of every person to worship God in his own way.

(3) Freedom from want.

(4) Freedom from fear.

The wise conciseness of these words matched the dreams of all good men that somehow and some day the whole world would find these freedoms a part of their way of life. But it has not been a dream which yet has found fruition in fact.

Since these words were spoken we have fought World War II. We have engaged in the bloody Korean conflict. We subsequently have landed our fighting forces on foreign soil under tenebrous skies of threatened war. We are and have been awed by the advent of nuclear weapons, and we sit in breathless amazement as man-made satellites pierce the heavens and circle beyond the earth. No longer is the moon the object of childish fancy as "a piece of green cheese," nor is the "man in the moon," sufficient explanation to satisfy

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the demands of our young for factual information. We are "shooting the moon," and no one doubts that before long we'll hit it.

While the scientists of the world have come into their own and now occupy a lofty perch in public acclaim, the leaders of government appear as perplexed as any of us in understanding what is going on, much less what to do about it all. No one seeks to find only a single answer as to what is wrong with the nations of the world and why they are behaving as they do. But, although the cure is difficult without isolating the cause, we might go along with Dr. Jerome D. Frank, associate professor of psychiatry at the Johns Hopkins Medical School.

In a recent article the Doctor traces a parallel between the behavior of nations today and some mental patients. Russia and the United States in particular may need some psychotherapy, he believes. Such national symptoms as denial, repetition compulsion, and the self-fulfilling prophecy are observable.

In the first, the patient attempts to deal with a massive threat by denying its existence, as witness the widespread unconcern in both Russia and the United States with civil defense against nuclear warfare. When the patient keeps repeating the very acts which cause trouble for him, called "repetition compulsion," there is rigidity of behavior that isn't healthy. Or when enemies cannot trust each other because each is forced to act in such a way as to justify the other's misgivings, we have another symptom called the "self-fulfilling prophecy."

While we are unable to do much about the neurotic behavior patterns of Russia, we might turn our attention to our own. And the best beginning is with ourselves at a local level. The dealing with a massive threat by denying its existence, by ignoring it or passing it by with minimum comment and attention, seems to find application in the American view of crime.

It is reasonable to estimate that there will be 3,000,000 reported crimes in our country for the year of 1959. That averages one criminal act for each 60 persons. It also con-

stitutes a 100% increase in crime since 25 years ago. Head-scratching among American police leaders parallels that of our government leaders in seeking solutions to international misbehavior. What are we going to do?

Explosive population increases have and will add to our problem of human misbehavior, but it does not justify the tremendous increase in crime. The latter is disproportionally greater. Within the next 22 years it is predicted that the population of the United States will increase from the present 175 million to between 215 and 244 million people. Unless the trend is away from misconduct, this will mean even worse human behavior for the simple reason that there will be more to misbehave. Again, what are we going to do about it?

I would like to suggest a possible approach to a course of new action available to us as policemen. It is the extension of our crime prevention efforts through the use and application of what is known as the behavior sciences. Some time ago we realized it was far better to prevent misbehavior than to wait for it to happen. It is better for the people we serve, and it is a precious means of cutting down on our own work. It simply makes good sense, just as it is more plausible to put up traffic lights at a dangerous intersection rather than sit around and scoop up the broken bodies and mangled metal.

The behavior sciences incorporate the findings and efforts of the sociologist, psychologist, psychiatrist, anthropologist and even the economist. They are directed at the basic causes for man's behavior. With a discovery of the causes, which can be labelled stimuli, we have a chance to control the responses.

We are concerned with juvenile behavior, but we are presently so limited in our ability to affect it that it is almost frustrating. Too often we come into contact with our youth after the bad deed is done, and take up from there. Let us assume that mass media influence on the young mind is firmly established in regard to television shows. Let us assume that it is an established fact that the violence of some shows, and especially nightly repetition of such violence, is harmful and encourages crime among our youth. Armed with these findings from the behavior sciences, the police could embark upon a campaign directed at parental control of this mass media influence through selectivity of programs.

As a major item in the police use of the behavior sciences looms the advocacy of psychological examinations of school children as a matter of routine. Our schools have for years and to varying extents taken it upon themselves to check the child physically. The ears are examined, the teeth are looked at, eye examinations are given, and the parents are advised as to results.

But the emotional problems of the child are left to manifest themselves first, then attention is given. We don't wait for the child to complain of a toothache before we check his teeth—why wait until he exhibits a mental or emotional disturbance before attention is given him?

The dark ages of viewing the individual as being "crazy" because he has a mental or emotional disturbance, of locking him up and forgetting him, are gone. Those who blush in shame because it is suggested that some member of the family needs psychiatric aid are of a diminishing and ignorant minority. The time is here for the police to engage in preventive "medicine" for potential misbehavior.

More and more the policeman is forced to admit that even with his modern weapons of fighting crime he is losing ground. How far back the enemy, gross misconduct, will push him before he adopts counter tactics is for us to decide. We must link hands with our educational leaders, our doctors and all of those who are able to attack crime and future crime through their present, daily fields of endeavor.

Misbehavior at all ages is more than just the commission of acts which society has codified into law-violations. It includes those activities which are not felonies nor misdemeanors, but nevertheless are destructive to society and to the individual himself. Divorce is predicated in many instances on non-criminal demeanor, but none the less is action clearly constituting misbehavior. There is no reason for the police to ignore all types of misbehavior beneath the level of criminal activity. To do so is to passively condone much that causes crime, and to do so upon the ground that it is without our scope of work to attempt constructive action.

We are armed by law to fight crime and criminal behavior; we are armed by the behavior sciences to fight misbehavior at all levels. We must enlarge our views of the scope of the

police function to include as a part of our function the attack upon conditions which breed crime, and to carry out that attack through positive methods modern behavior men are providing.

We make so much ado over obtaining a driver's license, but we ask few qualifications of those who marry and embark upon the rearing of a family. We do not concern ourselves with the advocacy of child training by enlightened, educated parents. No, we sit back and wait for the harm to be done to the individual through environmental factors that disease the mind with future misbehavior, then we complain that our work is heavy and we retreat another step in our ability to fight crime.

The unitary theory or concept of mental illnesses, many of which are the core of criminal behavior, is that the individual afflicted has become mentally and emotionally affected because he cannot adjust to his surroundings, to his family problems, to his working conditions, to any and everything that constitutes his particular place in life.

We must concern ourselves with all of the factors which cause this impairment of the ability to self-regulate to one's environment. Until we do, crime will increase as all types of human misconduct multiply.

I propose active police participation in a program which advocates the following steps toward better behavior:

1. More attention to the mental and emotional condition of the child at as early an age as feasible. This might be accomplished by psychological examinations given on the same basis as present physical examinations, with reports made to parents and teachers.
2. More vigorous inducement of parental education in the field of mental health both for themselves and their children. The forum and procedure for such instruction is admittedly a problem, but it can be accomplished through sincere efforts.
3. An enhancement of communications between the public and the police with more effective messages directed at crime prevention through better conduct. In

other words, an attempt to arrest the attention of the people so as to make unnecessary their physical arrest.

If we are ever to make strides in attaining President Franklin D. Roosevelt's greatest of his four freedoms, freedom from fear, we shall first have to make strides toward the attainment of a badly needed fifth freedom in America—that of freedom from criminality.

Some Problems Confronting the Psychiatrist and the Psychologist in Compensation Work[1]

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Workmen's compensation laws provide for compensation to be paid to an employee who sustains a disability resulting from his work. Understandably the medical expert is essential in assessing such a disability. It is now recognized that in particular cases disability on a functional or emotional level is as significant as the organic factors. Thus the opinions of the psychiatrist and psychologist more frequently are being requested by workmen's compensation departments and the legal profession.

I. THE PSYCHIATRIST

In compensation law we are confronted with the problems of whether or not a disability exists, what is its nature and extent, and how the disability is related to the person's work. The expert witness is frequently called upon to offer opinions on all three of these questions. When the disability is a

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psychiatric one, certain unique problems are presented, and I should like to consider them here.

First let us consider the question of objectivity (4). Psychiatric examination is essentially by interview; therefore the psychiatrist is actively involved with the individual he is supposed to be observing. What happens to objectivity in such a situation?

At this point I think we must pause long enough to examine the concept of objectivity in scientific observation. Actually there is no such thing as purely objective observation even in the so-called "absolute sciences." H. Cantril, in an article on "Perception and Interpersonal Relations," says:

> Our perception depends in large part on the assumptions we bring to any particular occasion. It is, as Dewey and Bentley long ago pointed out, not a "reaction to" stimuli in the environment but may be more accurately described as a "transaction with" an environment. This implies that the meanings and significances we assign to things, to symbols, to people, and to events are the meanings and significances we have built up through our past experience and are not inherent and intrinsic in the "stimulus" itself.

He offers some interesting experimental proof. Investigators in South Africa, using a stereoscope with a different picture in each slide, tested subjects with facial pictures of members of different races. For example, a picture of an Indian would be inserted on the left side of the stereoscope and a picture of a Zulu on the right. The subject would view the two simultaneously, one with each eye. In those instances where an Indian was involved, the majority of Zulus saw an Indian rather than a White or Zulu. The significance of this phenomenon can be appreciated only when we know that the Zulu experiences the Indian as his gravest threat and worst enemy. On the other hand, among white subjects a colored face (either Zulu or Indian) was seen in most instances where pictures of one colored and one white person were used at the same time. The white South African sees himself as literally immersed in a sea of color.

In another application of the same technique, a picture of a baseball player and a picture of a bull fighter were used with Mexican and American children. Most of the American children saw the baseball player, and most of the Mexican youngsters saw the matador.

So it becomes evident that all perception contains a large subjective element; and "objectivity" when applied to observation is, at best, a relative term. The difference between the pathologist who observes through a microscope and the psychiatrist who observes through an interview is quantitative. Sir William Dampier (3) in his "History of Science" remarks: "Men of science, most of whom used naively to assume that they were dealing with ultimate reality, are coming to see more clearly the true nature of their work. . . . The approach to reality through science, therefore, gives only aspects of reality, pictures drawn on simplified lines, but not reality itself." One is reminded of the three baseball umpires cited by Cantril who were discussing their hard lot. The first observed, "Some's balls and some's strikes and I call's 'em as they is." The next said, "Some's balls and some's strikes and I calls 'em as I sees 'em." Then the last one spoke up: "Some's balls and some's strikes, but they ain't nothin' till I calls 'em."

So much for the objectivity of perception per se, but there is another factor which is a complication peculiar to the psychiatric examination. Harry Stack Sullivan (11) reminds us:

> The psychiatrist cannot stand off to one side and apply his sense organs, however they may be refined by the use of apparatus, to noticing what someone else does, without becoming personally implicated in the operation. His principal instrument of observation is his self—his personality, him as a person. The processes and changes in processes that make up the data which can be subjected to scientific study occur, not in the subject person nor in the observer, but in the situation which is created between the observer and his subject. . . . There are no purely objective data in psychiatry, and there are no valid subjective data, because the material

becomes scientifically usable only in the shape of a complex resultant—inference.

To guard against distortion, it is essential that the psychiatrist be aware of his own reactions to and involvement with the patient at all times. It is for this reason that some type of personality inventory, usually psychoanalysis, is regarded as necessary for the present-day psychiatrist. For instance, it would be regrettable if a psychiatrist were to decide that a hysterical patient was a malingerer because this patient had aroused his anger by being arrogant or irresponsible. The patient who walks into an office with the challenge: "Are you the nut doctor? Don't know why they sent me here because I'm not crazy" (and then proceeds to burn a hole in the coffee table) may, in some instances, have a diagnosis hurled at him like an epithet. The psychiatrist may then rationalize his reaction by observing that this fellow has the attitude that the world owes him a living and is probably malingering to collect the debt. This is mighty flimsy and distorted reasoning. The patient *might* have anything from arteriosclerotic brain disease to an adult situational reaction.

The psychiatrist must also be aware of his tendency to be prejudiced in favor of his employers—to deliver the goods. The unfortunate pattern seems to be for a given psychiatrist to become categorized as either a "plaintiff's man" or a "defendant's man." A psychiatrist retained by the court may find it easier to be more nearly neutral.

Finally, the psychiatrist attempts to avoid subjective distortion by making his diagnostic impressions on a broad basis. No accurate appraisal can be made on the basis of a single finding. For instance, apprehension about his impending examination is characteristically found in the malingerer, but it is also encountered in a variety of neurotic and even psychotic disorders. As M. S. Guttmacher (6) puts it: "Mental disease is not something that affects this or that mental function; it is a disorder that pervades all the thinking, all of the feeling, and all of the activity of the individual." By maintaining this total view of the patient the psychiatrist can avoid many errors.

Next we must remember that the psychiatrist is a student of human behavior, a field in which most people, including lawyers, regard themselves as knowledgeable by virtue of experience. Such experience is implied in the terms "common sense" and "horse sense." Unfortunately, to assume that we understand human living because we have lived is as naive as to say that we understand the intricacies of gastrointestinal physiology because we belch.

As an expert witness I have on more than one occasion thought that I detected an attitude on the part of the opposing lawyer which seemed to say, "Come off it, doc; let's talk turkey; we all know so and so." Such an attitude is easy to assume because, to quote Guttmacher (6) again:

> Psychiatry deals almost entirely with imponderables. And, furthermore, the psychiatrist, by exercising his special skill, is able to make deductions about mentation in his patient which is occurring at an unconscious level and of which the patient himself has no awareness. Such data, which is an essential part of the examination, is difficult to demonstrate and impossible to prove."

Alistair Cooke (2), writing of the second Hiss trial, stated: ". . . that when a psychiatrist is in the offing, hell hath no fury like a layman scorned; and that the common man in the mid-twentieth century, ninety-four years after the birth of Freud, would still rather steer clear of the mysteries of emotional health, and that when they are invoked he is inclined to retreat into a down-to-earth protest."

I do not mean to categorize lawyers as laymen, but I am surprised at the number of compensation lawyers who are remarkably well informed on other phases of medicine and yet know virtually nothing of basic psychiatric concepts. In summary then, another common problem confronting the psychiatric expert witness is the hostility of those receiving his testimony: things psychiatric seem so frequently to flout their "good sense"—and sensibilities.

Last, we consider the question of the credibility of the complainant who is to be examined and who has a financial stake in establishing his alleged illness. The matter of the

reliability of witnesses in criminal trials attracted Freud's (5) attention as far back as 1906. At that time he addressed a law seminar on the subject of the word-association test with which the students were experimenting in their mock trials in an attempt to overcome the untrustworthiness of witnesses. In this test a stimulus word is given, and the subject is asked to reply with the first word that comes into his mind. Freud (5) established that "examples . . . make us doubt the existence of chance and of what appears to be arbitrariness in mental processes." Slips of memory, tongue, or pen; mislaying of objects; petty habits of playing or fiddling with things are all "symptomatic actions" connected with hidden meaning—a complex, which is a disturbing group of ideas in the unconscious.

Even the seemingly random choice of names or numbers doesn't occur by chance. When a person is asked to choose a number, unconscious factor's determine that choice. Modern science has recognized the inability of the mind to construct random numbers. We now have tables and machines to furnish us with random numbers which are necessary in some scientific work. Freud demonstrated this "conception of determinism in mental processes."

Bearing this fact in mind, we are ready to deal with the oft-raised objection that all psychiatric testimony is based on the veracity of the patient, that we have no choice but to parrot what the patient has told us. Nothing could be further from established scientific knowledge. In essence a patient's statements can be treated quite like his heart sounds. The heart sounds are one of several signs produced by an organ. The patient's words are one of several signs produced by the total organism. They are a part of his total behavior and cannot be divorced from it. As Sullivan (11) has said: "If one assumed that everyone who came to a psychiatrist . . . had to be pinned down . . . or cross-examined to determine what was fact and what was fiction, then interviews would have to go on for many, many hours in order to make any sense of the other person."

The psychiatrist is not confined to catching logical inconsistencies in the patient's statements. Unusual content in an answer, faulty reproduction of a question, persistence

on the patient's part in bringing up a certain subject after it has been passed over in the examination, delay in answering—all tell us that we are touching on disturbing material. A patient is asked if he drinks. After an inordinately long pause, he replies, "Oh, I have a beer now and then." The answer isn't unusual but the pause invites our attention to this area.

We dare not forget that the psychiatric interview involves primarily vocal rather than solely verbal communication. Intonation, rate of speech, difficulty in enunciation are as important as speech content. I once saw a patient who had been a union organizer. When asked about hospitalizations, he revealed that he had been in a state mental hospital. As he spoke of his hospitalization he developed a tremolo in his voice. For this reason I probed further in this area even though his reply had been fairly matter-of-fact. Gradually the delusion unfolded: to him, his commitment represented persecution for his union activities. When we add the patient's starts, his sudden changes in posture, and his facial expressions—and we are still omitting a great many observable items—we see what a complex picture behavior presents, even within the confines of a one- to two-hour interview, and how difficult conscious dissimulation becomes. One patient, who was complaining of nervousness, claimed that she had been nervous only since her accident. At this point she developed a gross tremor of the left hand. This occurrence would certainly arouse suspicion that some emotional symptoms may have existed before the accident.

The more unstructured the stimuli (usually questions in a psychiatric examination) the more difficult it is for the patient to know what he is revealing in his responses. For this reason many general questions are used. Here lies some of the value of psychological testing. It is frequently of great help to the psychiatrist to have available the results of such tests, as a further view of the patient's behavior, when he attempts to formulate the relationship of symptoms to total personality.

In evaluating the nature and extent of a mental illness the psychiatrist frequently calls on the clinical psychologists for help. As a final illustrative case, I cite a 29-year-old woman

who complained of severe pain at the base of her spine following a fall. The pain persisted even after surgical removal of the coccyx though all physical signs were negative. The psychiatric examination revealed an obvious anxiety reaction. However, inconsistencies in her history, the planning and preparation she revealed in telling her story, and the single-minded intensity with which she presented her case caused me to request psychological testing. With the evidence obtained by the psychologist added to my own observations, I was able to discern that this woman had a character disorder which made her relate to the company as to a gigantic parent figure at whose hands she could not tolerate frustration. The litigation was really an attempt to extract gratification from this figure.

An attempt has been made to outline some problems which the expert psychiatric witness encounters in compensation cases in attempting to determine the existence, nature, and extent of an emotional disability, and the possible relationship of said disability to the individual's job—problems which revolve around the objectivity of the psychiatric examiner, hostility to the psychiatrist's testimony, and the credibility of the patient seeking compensation.

II. THE PSYCHOLOGIST

Of the twenty major topical divisions of the American Psychological Association, only one has as its major interest the problem of measurement and evaluation. Nevertheless, the image of "the psychologist" which apparently captures the fancy of most people has him, stop watch in hand, measuring and probing by means of "I. Q." tests, word associations and peculiar ink blots.

It is true, however, that the history of psychology shows us to be more involved than any other group with mental measurement and test assessment of behavior. Psychology set out in the latter half of the last century to apply to a heretofore philosophical problem (the nature of mind) the methods and mathematics of science. One of the outcomes of this endeavor was the development of the "mental test," a term first used in 1890. The modern term is "psychometrics."

Today the testing movement has grown and proliferated to such an extent that a thick yearbook is needed to summarize the new tests and revisions of existing ones. Psychometric information may relate—to name only a few applications—to intelligence, interests, handicaps, contact with reality and emotional conflicts.

What is the value of tests, particularly as they might apply to legal proceedings?

1. Examination is relatively easy and brief. Usually testing can be completed in one sitting. No special facilities are needed beyond a quiet room, and no special equipment is needed beyond the test material. The testee does not have to prepare for the examination and the testing procedure is almost always acceptable to the testee.

2. Tests are relatively objective. While the objectiveness of observation is relative, psychologists have gone to some pains to make their test results as objective as possible, and in a number of different ways.

The first of these is through the employment of standardized tests and norms. A standardized test is one in which the test items, methods of scoring, and manner of administration are all fixed or specified; hence every testee is examined under the same conditions and with the same items, so that it is possible to analyze the findings for large groups of people and to set up norms for various groups—"normal" individuals, brain-damaged persons, psychotic patients, etc. Thus, in evaluating a given problem, the examiner knows in advance at least one general characteristic of his test group. Standardized tests and norms are not a substitute for experience but when wisely used, magnify it, and of course, aid in minimizing subjective distortions.

Another aid to objectivity is the fact that the client's test responses are taken down verbatim; indeed, where non-verbal tasks, such as drawings, are undertaken, the testee himself produces the record. This type of recording reduces distortions arising out of the examiner's selective recall of what the testee did or said. There are at least two other advantages to having a complete record of responses: if retesting is called for at a later date, as is sometimes the case in judging changes in the client's condition over a period of time, the

psychologist can readily compare findings. Moreover, many of the test findings are in graphic or pictorial form, a clarifying factor when the examiner must present his findings to someone unfamiliar with the tests.

3. A testee often reveals more than he intends or realizes. Many of the test stimuli are unfamiliar to him, and so vague or unstructured that he has no idea of what might be considered an "acceptable" response or an answer consistent with the impression he wishes to create. The Rorschach ink blots are a good example of this ambiguous type of test material.

4. The expected range of responses for various groups to each test item is known at the outset; therefore each test item is a test in itself. The psychologist actually secures in the course of a testing session involving a wide variety of tasks several hundred miniature samples of behavior. He will be able to document his major conclusions with many such observations, and will build up a reliable picture of the patient's functioning in any one respect with numerous cross checks on the patient's internal consistency.

5. Finally, the psychologist utilizes tests as a separate means of gathering further confirming or rejecting data about a given problem. The conclusions reached on the basis of psychological examination show a relatively high degree of agreement with results of other methods of evaluating the same condition; thus it is possible to correlate findings.

Now, lest we build up an unrealistically favorable picture of tests, let us consider their limitations.

1. The first of these is the rigidity of inquiry—the obverse of one of its major advantages, its standardized procedures. The non-testing interviewer can range over any number of topics and probe where he finds salient material. He can be as flexible in his approach as he needs to be. The test examiner, to be sure, may also interview the client and often does before or after the tests; but he cannot claim about the results so elicited the special advantages of the testing situation. His findings are usually combined with other data to form a composite "fleshed-out" picture of the client.

2. There may be a problem in communication between the psychologist and lawyer because their language and concepts

often differ. Writing on this topic, McCary (8) refers to "the disturbing discrepancies between the modern science of human behavior and the relatively fixed and archaic 'psychology' of law." The lawyer wants to know, if possible, concretely, categorically and with certainty; the psychologist, who shares with the psychiatrist the same basic fund of findings and concepts, often deals not in facts but in probabilities. He sees tendencies of behavior, sometimes conflicting tendencies of which the client may not be aware. Psychologists, in their efforts to be precise through their qualification of findings, must at times seem muddle-headed to the lawyer. A process of mutual education is needed.

3. There is still some confusion concerning the kinds of problems in which the psychologist can qualify as an expert witness and the extent to which he can testify about the problem in question. McCary (8) and Louisell (7) have treated this problem in some detail in recent papers. The problem of the psychologist's precise status as an expert has arisen partly because few appeals to a court of record have taken place until recently; the psychologist as expert has a new and rather hazy legal status. The expected rapid accumulation of such rulings should do much to clarify this matter.

A related problem of which the lawyer should be aware is that many states have no licensing or certification of psychologists. As one writer pointedly states: "As long as any quack can call himself a psychologist, there is going to be resistance to granting the mantle of the expert witness to psychologists as a class." Psychologists through their state associations support appropriate legislation to protect the public against unqualified self-styled "experts" (8).

Whatever the drawbacks, psychometrics appear to be gaining favor. To quote from a review by Schofield (10): "Psychology is occasionally called upon to serve the courts in increasingly diverse and appropriate ways. There will be a growing demand for the assistance of professional psychologists, particularly in compensation litigation involving head trauma and in cases where there is a plea of insanity." It would appear that while this union like most, is not made in

heaven, psychologists and lawyers will be developing a closer working relationship than they have achieved in the past.

Let's turn now to specific test procedures, considering first a client with possible brain damage; many points are easy to illustrate in this kind of problem. There is no fixed battery or group of tests which the psychologist necessarily employs but there are published findings for many tests against which the client's performance can be checked. Our psychologist might begin with a standardized intelligence test, such as the Wechsler Adult Intelligence Scale. This test is composed of eleven sub-tests, some of a verbal type (general information and vocabulary, for example) and others of a non-verbal type (the working of a kind of picture puzzle, for example, or constructing designs with blocks). Each of the responses the client gives and each of the scores the sub-tests yield is compared with a norm, in this case the expected attainment of individuals the same age as the client. There are other published findings of various clinical groups, including the brain-damaged. So it is possible to say that the client in his intellectual functioning is similar to or different from the normal or brain-damaged individual in one or more respects. In the normal individual one expects a relatively even pattern of attainment, but except in the most grossly limited brain-damaged individuals who would probably not be in litigation anyway, one tends to find selective impairment. One area frequently affected is that of abstract thinking; the brain-damaged individual tends to think in concrete, literal terms. The "Similarities" sub-test of the Wechsler taps this kind of mental operation. When asked to give the similarity between praise and punishment, a coat and a dress, an ax and a saw, for example, the client must abstract common properties to form an acceptable response. The client who gives differences, cites inferior similarities or perhaps is unable to comprehend the task, presents a striking finding, especially if his scores on other sub-tests (such as general vocabulary), which are usually less sensitive to the impairing effects of brain damage, are relatively much higher. Another sensitive sub-test is the "Block Design" sub-test. The brain-damaged person not only has frequent difficulty here but usually has a particular kind of difficulty. Anyone can fail one or more

of these designs, even by intention, but the brain-damaged person, for example, is one of the few who is likely to give a spurious solution and to be unable to tell that it is incorrect. So one proceeds to evaluate the findings of this test, relating one score to the other and comparing them all to the overall I. Q. determined as a composite measure.

The psychologist then might proceed to a standardized test of memory, an area of common impairment in the brain-damaged person. Items of the Wechsler Memory Scale (12) are scored for recent and remote memory, memory for familiar and unfamiliar associations and memory for verbal material as well as for designs. The internal consistency of the client's performance is evaluated against known expectations and against the results of the intelligence test, which also contains some memory items. And the memory test yields a score too, an M. Q., which should compare within certain limits with the Wechsler I. Q. in the normal, since the tests were so devised. If these two scores are discrepant, an explanation is called for. In one striking instance an individual scored an M. Q. 40 points lower than his I. Q. What did this mean? Probably that while his overall intellectual functioning showed little impairment, one selected aspect, memory, was grossly impaired.

There are still other tests the psychologist may apply before drawing conclusions. He may have the client copy geometric designs. The normal has no difficulty, the brain-damaged typically has, but in certain ways. Crude or poorly executed figures are not a convincing indication. Difficulty in angulation, however, or in bringing closure are typical signs. He might give the Rorschach ink blots next. How does the client do here? Does he give only a few responses? Are some of them most unusual as compared with what is expected? This is not enough to convince the psychologist of brain damage. But if the patient says, "All I can see here is a line; I know that's very poor but I just can't do any better," showing signs of anxiety over his lack of ability, we may be dealing with an organic syndrome. Piotrowski (9) has dubbed this kind of behavior "impotency." Another symptom typical of the brain-damaged but rare in other groups is the use of pet phrases repetitively despite their inappropriate-

ness, and there are a number of others. If several occur in the same record, they are of diagnostic significance. Now, maintaining his process of cross-checking, the psychologist compares the Rorschach findings with the others. Suppose the client produces predominantly well-integrated responses to the Rorschach but has done very poorly on the Wechsler Intelligence or Memory Scales. This is not a "normal" finding. The psychologist may apply still further tests until he has satisfied himself that he has an adequate sample.

I have tried to show that the client is compared not only with external groups but also with himself, for consistency and reliability of performance; and only when a significant pattern emerges does the examiner consider brain damage to be highly probable. The painstaking process of psychological evaluation for brain damage with its many built-in checks and balances is probably responsible for the fact that there are few false positives, more false negatives.

I'd like to close by citing a different kind of problem, one in which the psychologist had fewer external norms or references on which to depend than he had found in his testing of the brain-damaged individual. I refer to the personal problem of the woman already mentioned who was seeking compensation for a back injury incurred at her place of work. In this case it was necessary for the psychologist to put more weight on his interpretation of the data which she presented.

Because of her difficulties the woman in this case was referred for psychiatric and psychological examination. The client came into the psychologist's testing room prepared to relate her unfortunate story. The psychologist listened to her politely for a few minutes but was not at all interested in the details of her accident. When faced with the tests, the client became uneasy. What was she to say? Was the method indirect. She did poorly on the intelligence scale, but in a way that did not indicate that she was a constitutionally dull individual. She did very well with some items of considerable difficulty and failed others that were simple. Only the examiner was aware of the inconsistency. He began to note a trend in her responses. On the Wechsler Intelligence Scale, for example, when asked one of the routine questions—"Why do we have child labor laws?"—she gave an

unusually long and heated reply to the effect that such laws were necessary to keep innocent children from being exploited by their parents. The law, she said, was a blot on the record of society, for it indicated that parents did not love their children enough to protect them from the evils of the shop and factory. Why this exposition on this particular question and yet matter-of–fact responses to a dozen or more questions dealing with other matters? It must be, reasoned the psychologist, that the topic of child neglect meant something special to her. On the Rorschach she described a number of small animals, somehow strayed from their nest or lair, being pursued by predators. The "story" was different, but she was really saying the same thing—that these were neglected children, too. Here also it was unconscious factors within her that caused her to describe such things: the blots are ambiguous, and any number of other things can be seen in them. They went on to the Thematic Apperception Test, which consists of picture cards usually depicting persons whose activities and expressions are unclear or ambiguous. This is a more structured test than the Rorschach, but there is much left for the client to imagine, according to her particular needs. Here she produced stories of family discord, of abandoned and neglected children; in one example the daughter who returned home after an absence so resented her mother that she started to tell her off, lost her temper and began to choke her.

On the basis of findings such as these what could the psychologist say? First, that this woman had some serious emotional problems which caused her much unhappiness. Second, that she had a strong need for vengeance against those, basically her parents, who she felt had neglected her and had not given her the love she expected. Third, that because she saw most circumstances as in some way a re-enactment of this basic frustration, she probably viewed her employer as a "bad parent" from whom she fully expected gratification (in this instance money) in an attempt to meet these emotional needs. It would appear that the contemplated litigation was a kind of funnel into which the major problems of her early life had been poured. We would expect that to serve this end she had every reason to exaggerate or even

create physical symptoms. The test results could not prove she did not actually have a disabling back injury, but they aided in providing an alternate explanation for her litigation efforts which rendered suspect her claim of organic damage. The test results when combined with the material of the psychiatric interview made possible a fuller and better documented picture of the client than would otherwise have been obtained, and aided in placing the problem within a frame of reference from which constructive and appropriate recommendations for the client could be made.

The major value of psychological tests is the means they provide to elicit relatively objective information about matters where objective and reliable information is difficult to obtain. However, they are no magical solution; they do not supplant other established tools of evaluation, but should be used in combination with other methods of study.

Summary

With the growth of the body of compensation litigation involving claims of functional disability, the particular skills of the psychiatrist and psychologist as expert witnesses are in increasing demand. This paper has offered examples of the approaches of the two disciplines to these complex problems as well as a discussion of their respective advantages and difficulties. Emphasis has been placed upon the problems of the objectiveness of examining procedures and findings, the credibility of the witness and the defensive reactions aroused to testimony dealing with emotional disturbances.

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The Traumatic Pathology of Traffic Accidents*

The Review of 302 Autopsies**

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Until recent years little has been written in medical literature about the specific injuries sustained by traffic accident victims.

Much of the basic work on this problem has been done by the Cornell Medical College Auto Crash Injury Research Program. This has included experimental studies of crash situations and epidemiological studies of actual accidents and the resulting injuries to the victims. The latter studies have been accomplished through the close cooperation of the medical, public health and police groups of 12 states.

It is unfortunate that much of this technical material does not reach those of us who are concerned with the traffic accident victims as clinical and autopsy cases. Thus we may not appreciate the massive traumatic forces to which these

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persons may have been exposed and the variety and multiplicity of the injuries that result.

It is our purpose to present the findings in a large series of autopsied traffic fatalities and point out how injuries vary according to the specific accident situations and the position of the victims within or outside of the vehicle at the time of the accident.

This study is based on a review of the autopsy protocols and accident reports of 302 autopsied traffic fatalities which were investigated by the direction of the Coroner of Orleans Parish, New Orleans, Louisiana. It includes all traffic victims autopsied during the two-year and nine-month period from May 1, 1954 to January 31, 1957. Traffic injuries that did not result in death are not considered in this study.

A parallel study of the medical management of these cases is being prepared by Dr. William Kemmerer of the Tulane Surgical Service, Charity Hospital, New Orleans, Louisiana.

The five general types of accidents included in this study are Auto-Pedestrian, Auto-Auto, Off-the-Roadway, Cycling and Auto-Train accidents (Table 1). Each accident has characteristic types of trauma associated with it and these will be discussed under the specific accident type.

TABLE I

Classification and Incidence of Traffic Fatalities (302 cases)

		Cases	Percentage
I.	Auto-Auto accidents	92	30
II.	Off-the-Roadway accidents	73	24
III.	Auto-Pedestrian accidents	121	40
IV.	Cycling accidents	9	3
V.	Auto-Train accidents	7	3

Basic Concepts of Mechanisms of Injury During Accidents

Much of the original work in the mechanics of injury under force conditions has been performed by De Haven (1).

It is not within the scope of this paper to discuss the physics of the forces which play a role in traffic accidents but it is felt that some basic concepts should be mentioned so that the magnitude of trauma and multiplicity of body areas involved may be better understood.

The occupant of a vehicle or the rider of a cycle receives absolutely no harmful effect from the speed or velocity at which he is traveling. The extent of trauma which is sustained depends directly on the circumstances under which the various parts of the body are decelerated or accelerated. Thus many of the injuries result from the contact of relatively small body areas with the steering assembly, the windshield, the dashboard, window posts, handles and knobs during the accident. The whole body is also exposed to forces of great magnitude for short periods during the accident.

The "G" formula has been used to calculate just how much mean force is experienced in a "real life" accident (2).

$$G = \frac{V^2 \times .034}{D}$$

where G is equal to the force exerted by gravity, V is the velocity of the vehicle in miles per hour, .034 is a mathematical conversion factor and D is the stopping distance in feet.

For example if a car traveling at a speed of 50 m.p.h. strikes a dirt bank head on, and plows ahead 6 inches before full deceleration occurs, a mean force of 170 G's results. A car occupant weighing 150 pounds would theoretically be exposed to 25,500 pounds of force (gravity x body weight) in this accident situation. Actually, the occupant is usually decelerated at a much slower rate than the vehicle and his stopping distance is much longer.

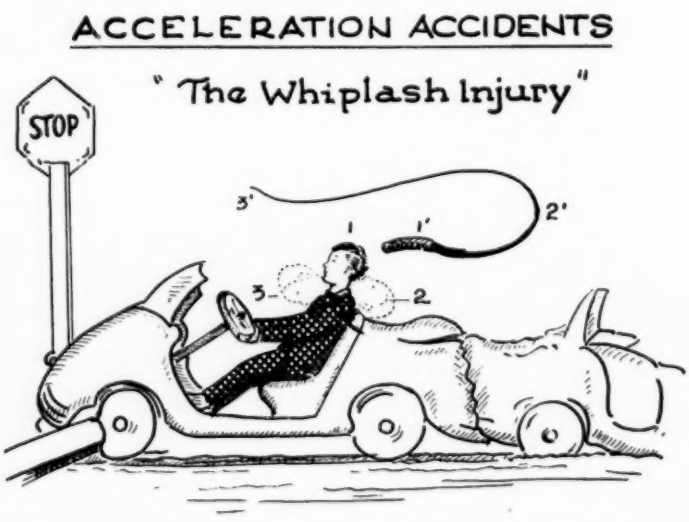
Despite these massive forces many victims of auto accidents have been exposed to greater magnitudes of force and have lived. De Haven's study of survivors of free falls up to 150 feet has shown that the body may tolerate and expend a force 200 times that of gravity for brief intervals during which the force acts in transverse relation to the long axis of the body (1).

In car occupants where the forces are not evenly distributed over the entire body one can readily understand how extensive injury may result when such great magnitudes of force are concentrated on a few square inches of body area.

Ejection after initial deceleration impact increases the multiplicity and severity of injury (3). The risk of fatal injury in an accident is increased 5-fold when a car occupant is ejected.

Acceleration or the so-called "whiplash" injury is a peculiar type of injury which occurs after rear impact and usually at low speeds. The victim suffers violent extension of the neck followed by flexion (Fig. 1). The cars may be but slightly damaged but the car occupants may suffer severe injuries to the neck.

FIGURE I



Discussion of Specific Accident Types

A. Combined Auto Accidents (Auto-Auto and Off-the-Roadway).

In examining the means by which the car occupant may be injured in Auto-Auto and Off-the-Roadway accidents, we find that in almost all instances the fatal injury results from deceleration impact with or without ejection. Thus we shall discuss these accidents as a combined group.

Victims of the combined group of auto accidents make up 54% (165 cases) of the traffic fatalities studied. 56% were passengers [1] and 44% were drivers (Table II).

In the combined group many accident situations were seen:

(a) Simple two car collisions (head on, side or rear impact).
(b) Complex collisions with overturning or running off the road.
(c) Single car accidents with running off the roadway into a fixed object, a bayou or overturning.

TABLE II

Combined Auto-Auto and Off-the-Roadway Accidents

(Distribution of 165 Deaths According to General Accident Type)

	Non-Ejected (132)		Ejected (33)	Total
	Deceleration Impact	Acceleration and Miscellaneous [2]		
Driver [3]	55	7	15	77
Passenger [4]	62	8	18	88
	117 (71%)	15 (9%)	33 (20%)	165 deaths

1. Non-Ejected Victims. Violent contact of the non-ejected car occupant with many structures in the car may be responsible for severe injury during the crash impact. In order of importance these are the steering assembly, instrument panel, windshield, backrest of front seat, door structures, front corner post, flying glass, top structures and rear-view mirror.

The driver in most accidents sustains injury as a result of striking the steering assembly, the dashboard, the window frames, windshield or roof. The front seat passenger is most

[1] 12% (11) passengers were in the rear seat.
[2] Miscellaneous—drownings, electrocution, cremation.
[3] See Table III for comparative risk of fatal injury to drivers and passengers.
[4] 11 were rear seat passengers.

often injured by striking the dashboard and windshield. The rear seat passenger sustains injury as a result of striking the front seat or doors, or by being thrown over the front seat and striking the car's front structures or the front seat occupant.

It must be remembered that although frontal impact is most commonly seen in auto accidents, the occupant may also be exposed to lateral and rear impact collisions. During lateral impact collisions the car occupant may be exposed to larger magnitudes of force as there is very little of the car structure intervening to cushion the impact as is the case in frontal impact accidents. During rear impact the victim is exposed to abrupt acceleration and excessive movement of the neck is a major factor in producing injury.

There were so few rear seat passengers among the non-ejected fatalities that no definite conclusions could be drawn about their injuries. Thus for all intents and purposes the non-ejected cases will include only front seat occupants.

In general there was little difference in the frequency of the sites of injury between fatally injured drivers and passengers. However, a driver is less likely to suffer fatal injury than a passenger in the same car (Table III).

TABLE III

Comparative Risk of Fatal Injury to Drivers and Passengers

Combined Group of Auto Accidents [5]

A.	Accidents in which two or more persons were present in the car but only one was fatally injured	80 accidents
	(1) Only the driver was killed (80 drivers)	7 (9%)
	(2) Only the front passenger killed (106 front passengers)	65 (61%)
	(3) Only the rear passenger killed (44 rear passengers)	8 (18%)
B.	Ejection fatalities in which two or more persons were in the car but only one was killed	10 accidents
	(1) The driver alone ejected and killed	2
	(2) The front passenger alone ejected and killed	6
	(3) The rear passenger alone ejected and killed	2

[5] Drivers 80
Passengers 150
Front 106
Rear 44

The sitting position with the trunk flexed is the usual attitude that the front seat occupant maintains when he strikes the car structures in frontal impact situations. Thus the head, chest, abdomen and knee are the primary points of impact of the body with the forward car structures. These are the most frequently injured body areas in both non-ejected drivers and passengers (Table IV).

Combinations of injuries were important factors in the fatal outcome of many of these victims. Severe injuries of the head, chest, abdomen and legs were seen simultaneously in many cases. Combinations of injuries involving two or three of these body areas were common.

TABLE IV

Combined Auto Accidents (165 cases)

Percent Frequency of Injury to Specific Body Areas

	All Cases (165)	Drivers (55)	Non-Ejected [6] Passengers (62)	Both (117)	Ejected (33)
Head	54 (48%)[7]	58 (60%)[7]	59 (36%)[7]	59 (48%)[7]	62 (50%)[7]
Neck	15	13	8	10	9
Chest	52	49	52	50	67
Abdomen	37	31	34	33	52
Pelvis	5	4	10	7	7
Extremity	43	35	50	43	24
Upper	13	15	14	15	10
Lower	30	20	36	28	14

The head is injured in about three out of five non-ejected fatalities. There was almost exactly the same frequency of head injuries in general in the driver and the front seat passenger fatalities but skull fractures were almost twice as frequent in drivers as in front seat passengers. This difference is difficult to understand but one may speculate that if the front seat passenger strikes the windshield, this structure may give little resistance and may burst out. The victim's head may go on through the windshield and strike the

[6] Exclusive of miscellaneous and acceleration accidents.

[7] Figures in parentheses show percentage of head injuries with skull fractures.

car's hood. Thus there will be a greater period of deceleration and less associated massive force concentrated on a small area of the head. The driver on the other hand is prevented from striking the windshield directly because of his contact with the steering wheel. His head may strike the roof or window frame and it is thereby exposed to a shorter period of deceleration and greater likelihood of skull fractures.

Both drivers and front seat passengers are exposed to the whiplash injury during rear impact collisions but this was an infrequent type of accident. It occurred in only 5% (6 cases) of non-ejected occupants.

The driver sustains chest injury by striking the steering post and the front passenger by striking the dashboard. Rib fractures were the most frequent chest injuries, regardless of the occupant's position in the front seat. In several instances these were associated with pleural tears and/or lung trauma. Heart contusions and rupture of a major vessel were seen in cases where the major forces were directed to the sternum. These were seen in both drivers and front seat passenger victims. The sternum was fractured in most of these cases.

The abdomen apparently is spared a direct blow in many instances. This may be due to the fact that in the attitude at which the body strikes the forward car parts the abdomen is partially protected. This area was injured in one third of the non-ejected cases. The liver and spleen were the most frequently injured abdominal viscera. They were injured with about the same frequency in the front seat occupants regardless of the position. The liver was injured more frequently than the spleen in drivers. Injuries to several viscera in the same victims occurred in less than one third of non-ejected victims.

The pelvis was injured infrequently in non-ejected cases. There was a slightly higher incidence of pelvic injuries in front seat passengers than in drivers.

The impact of the knee against the dashboard and protruding structures was responsible for a large number of injuries to the femur in non-ejected front seat occupants. The slightly lower incidence among drivers may be due to the fact that the steering assembly may prevent the driver's knee

from striking the car structures with as much force as the passenger's would.

Bracing or braking immediately prior to an imminent collision may result in fractures of the tibia or fibulae and the upper extremity in these cases.

2. Ejection Fatalities. Ejection from the car resulted in severe and multiple injuries to occupants regardless of their original position in the car.

In our series 20% (33) of the victims of the combined groups of auto accidents were ejected from the vehicle. In accidents in our series where there were one or more persons in the car and one was ejected and killed we found that the victim was more often a passenger than the driver (Table III). There were, however, no significant differences in the nature of the injuries suffered by ejected passengers and drivers. We will consider ejection fatalities as a group.

Ejection was found to be second only to steering post trauma as a major cause of injury in the large series of cases studied by the Cornell group (3). Ejection is largely dependent on the frequency with which doors are sprung open and there is a significant increase in the frequency of doors opening in roll-over accidents (77%) as compared with non-roll-over accidents (56%) (4). It was also shown in the study of Moore and Tourin (4) that when front doors opened in an accident one out of every three occupants was completely ejected from the car. From the general study conducted by the Cornell group, the risk of fatal injury as related to ejection or non-ejection was 5 to 1 (3).

In evaluating the injuries in ejection fatalities one must always consider that even before ejection the victim may have sustained severe and possibly fatal injuries. In ejection fatalities one is struck by the frequency of severe multiple injuries, any one of which might have been responsible for death. The head, chest and abdomen bear the brunt of the impact in ejected occupants (Table IV). The head alone or in combination with the chest and abdomen is injured severely in two out of three cases. The chest and abdomen alone, in combination with each other or with the head are injured severely in over half the ejected victims.

In considering specific injuries in these three regions we find that there were about the same frequency of skull fractures as severe brain injuries without skull fractures, and that rib fractures occurred in two-thirds of these cases. In about half of the chest injuries there was severe damage sustained by the intrathoracic viscera. The liver was severely injured in over a third of the ejected cases. Liver injury in combination with that of another abdominal viscus occurred in about half of the ejection victims who sustained abdominal injury.

B. Pedestrians.

Pedestrian fatalities made up 40% (121 cases) of the deaths in this study (Table V). In so far as can be determined, the injuries incurred during these accidents are produced most frequently by the initial impact. The pedestrian may in addition be thrown great distances and may sustain severe injuries as a result of striking the pavement or another fixed object. He may also be crushed after initial impact. Injuries resulting from pure crushing trauma are most frequently incurred when children crawl or run under vehicles.

TABLE V

Fatal Pedestrian Accidents (121 cases)

Mechanism of Injury

A.	Primary Impact	92%
	(1) Alone	62%
	(2) With throw	16%
	(3) With crush	14%
B.	Primary crush	8%

In most cases the pedestrian is first struck below the knee by the car's bumper. The pelvis, abdomen and chest will absorb additional impact in that order as a result of striking the radiator, fender or hood of the car. At the time of primary impact the body is exposed to great force depending chiefly on the speed of the striking vehicle and to a much lesser extent on the victim's body weight.

The lower extremity was severely injured in over two-thirds of the pedestrian victims. So called "bumper fractures"

or compound comminuted fractures of both the tibia and the fibula were the commonest injuries (53%). Fracture of one bone without the other was unusual. Bilateral fractures were seen in over one-fourth of the pedestrians with leg injuries. The femur was fractured together with the lower leg in 11% of the cases and separately in 6% (Table VI).

The pelvis was injured in about one-third of the pedestrian victims, most commonly as a result of primary impact. In some instances, particularly when the pelvis was crushed by a car wheel, massive fractures, or separation of the symphysis pubis or the sacro-iliac joint resulted.

TABLE VI

Pedestrian Deaths (121 cases)

Percent Frequency of Injury to Specific Body Areas

	All Cases (121)	Primary Impact			Primary Crush
		Alone	With Throw	With Crush	
Head	61	71	50	30	60
Neck	4	4	6	5	0
Chest	50	52	50	50	30
Abdomen	29	27	4	30	20
Pelvis	29	40	12	15	0
Extremity					
Upper	13	16	0	15	10
Lower	64 [8]	83	12	35	12

The abdomen is usually injured by primary impact or by being crushed directly by a car wheel. We did not encounter any penetrating wounds of the abdomen. The liver and spleen were injured with about equal frequency (52% and 47% of pedestrians with abdominal injury). Both the liver and spleen were injured in 12%. Multiple injuries involving more than one abdominal viscus were observed in 40% of the pedestrians with abdominal injury.

The chest was injured in half of the pedestrian fatalities. Rib fractures were present in 67% of these. One out of four pedestrians with chest injuries had injury to one or more of

[8] Tibia and Fibula Fractures 53%
Bilateral Tibia and Fibula 28%
Femur 17%

the intrathoracic organs associated with rib fractures. However, it is important to note that one-third of the intrathoracic injuries occurred without fracture of the ribs. The lung was the most frequently injured thoracic organ (33% of all chest injury cases). The neck was injured in only 4% of pedestrians.

Head injuries occurred with great frequency in pedestrian fatalities (61%). Two-thirds of these victims sustained skull fractures and associated brain trauma. Subdural hemorrhage or hematoma was present in 47% of head injuries. Skull fracture was absent in 38% of the subdural hematomas. Epidural hemorrhage followed skull fractures in three cases. The most severe damage to the head was present, as might be expected, in those cases where the pedestrian was run over and his head crushed.

C. Cyclists.

The injuries sustained in fatal cycling accidents appeared to result less often from initial impact than from throwing and impact of the rider with the ground or other fixed objects. Although this group makes up a small number of the entire series it is evident that the most frequently injured part of the body is the head. The frontal region of the head was the initial point of impact in most of our cases (Table VII).

It is interesting that in Great Britain, cyclist fatalities are second only in frequency to pedestrian fatalities whereas in the United States they make up a trivial proportion of cases (6).

TABLE VII

Auto-Train and Cycling Accidents

Percent Frequency of Injury to Specific Body Areas

	Auto-Train Accidents (7 cases)	Cycling Accidents (9 cases)
Head	85	88
Neck	0	0
Chest	85	33
Abdomen	85	22
Pelvis	0	22
Extremity	56	11

D. Auto-Train.

The auto-train fatalities make up only 3% of the cases in the entire series.

At the time of an auto-train collision, the car, because of its much lighter weight, has a similar relation to the train as a pedestrian to a car. Thus the car may be struck and thrown or struck and crushed. The occupants of a car are thus exposed to tremendous forces of impact. They may also be ejected or crushed and buffeted within the car. The injuries resulting from this type of accident were the most severe and complicated that were encountered in the study (Table VII). Serious head, chest and abdominal injuries occurred in most of the victims. Surprisingly enough, three cases in this group lived for more than 24 hours.

Discussion of Injuries in Specific Body Areas

A. Head Injury.

Of all regions of the body the head was the most frequently injured and head injury was the greatest single primary cause of death in the entire series. This occurred in over 50% of the victims of each accident type and in almost two-thirds of the occupants who were ejected from automobiles.

Skull fractures were the most frequent of the head injuries and were often associated with severe primary or secondary brain injury and hemorrhage. Occipital skull fractures occurred most commonly in pedestrians who had been thrown to the pavement after initial impact. Basilar skull fractures were seen with great regularity in cases where the frontal region was the initial area of impact. Severe injuries to the soft tissues of the face and maxillofacial regions were frequent in the front seat passengers and ejection victims.

B. Neck Injury.

The neck injuries were infrequent and occurred almost exclusively in auto-auto and off-the-roadway accidents. Apparently the most frequent cause of injury to this area is compression secondary to initial impact of the head with the car interior. Whiplash injury occurred in only a few of the car occupant victims. It is interesting that neck injuries were uncommon in the ejected victims. Dislocations and fractures

of the cervical vertebra with or without cord injury were the most frequent injuries to the neck.

C. Chest Injury.

Chest injuries were the second most common primary cause of death. The chest was injured with about the same frequency in the driver and the front seat passenger in deceleration accidents (59%). Those accident victims who were ejected suffered a slightly higher incidence of severe chest injuries than those who were not ejected (67%).

It is difficult for one to appreciate the amount of distortion of the rib cage that may occur when the chest is forcibly thrust against the steering post or dashboard. The compressibility and ability of the chest to return to a normal configuration is an important point for the surgeon or medical examiner to bear in mind, as ribs may be fractured and the lung, heart or liver punctured with little external evidence of injury or residual distortion of the rib cage. Rupture of the heart or a major vessel may be seen unassociated with rib fractures. These lesions must result from an increase of the intraluminal blood pressure to fantastic levels in consequence of sudden compression of the chest or possibly the abdomen. Complete or partial rupture of the aorta was found in 6% of all cases with chest injuries.

D. Abdominal Injury.

Injuries to the abdominal viscera were found with great frequency in those pedestrians who were crushed after primary impact and car occupants who were ejected. The incidence in the entire series was 30%.

In many cases only one abdominal organ was injured, indicating that the force was concentrated in that specific area of the abdomen. Thus a ruptured or torn kidney in the absence of injury to any other organ indicated localized force to the flank or posterior abdominal region on that side. A finding such as this may be important in pedestrian accident cases in determining the victim's position at the time of the impact.

Multiple abdominal injuries were seen most commonly in cases where the abdominal region sustained direct trauma

from a car wheel or from the vehicle rolling over on the victim.

The liver was the most frequently injured abdominal organ. This is understandable from its position, size and friability. In several cases of severe liver injury pre-existing liver disease was present. Thus large fatty livers were found in several cases and in one there was a heavy infestation with the larvae of the parasitic worm, *Toxicara canis*.

Gastro-intestinal tract injury was the most common abdominal injury in pedestrians injured by primary impact. One must keep in mind antecedent disease of the bowel as a factor that may determine the occurrence and site of a rupture when tremendous forces are applied to the abdomen. For example, traumatic rupture of a diverticulum of the colon with resulting peritonitis was the cause of death in one pedestrian. Of all the abdominal viscera that may be injured the kidneys were the least frequently involved. However, injuries to the pancreas, adrenals and gall bladder were not seen in our series. Injury to the abdominal aorta was infrequent (3 cases). It is interesting that in these three instances rupture occurred in the wall of a pre-existing arteriosclerotic aneurysm.

E. Pelvic Injury.

The pelvis was injured in 10% of all cases in our study and in one out of every five pedestrians.

The pelvis may be injured in several ways. A force of impact exerted directly or indirectly may drive the femoral head through the acetabulum. This usually shatters the pelvis with wide separation of bone fragments. A severe frontal impact over the symphysis may cause transverse fractures across the pubic rami. Forces of grinding or crushing nature such as may be produced by auto wheels can result in separation of the symphysis pubis or sacro-iliac joints as well as fractures of the pubic rami and sacrum. Among the many complications that may arise from pelvic injury, retroperitoneal hemorrhage was the one most frequently encountered in these traffic victims. The hemorrhage may be massive, causing immediate shock, but in many instances it progresses gradually over a period of hours. When major pelvic vessels

are punctured by bone fragments or torn during separation of the sacro-iliac joint, shock develops rapidly. An interesting entity seen in many elderly pedestrians is the slow development of a large retroperitoneal hematoma associated with massive edema of adjacent retroperitoneal tissues. Electrolyte imbalances have been noted in these cases and have been considered important as contributory causes of death.

F. Extremity Injury.

In pedestrians, compound comminuted fractures of the tibia and fibula, "the bumper injury," is very common and particularly in elderly patients it may be responsible for fatal shock. As previously noted, this injury is bilateral in about one out of four cases. The femur is fractured less frequently in pedestrians.

In car occupants involved in fatal deceleration accidents the femur is fractured in one out of five victims while fractures of the tibia or fibula are much less frequent. The mechanism of injury to the femur has already been mentioned. The tibia and fibula may be injured in front seat occupants who brace themselves before impact, thus bringing the major forces to bear on the lower leg. Lower extremity fractures are of much more significance in the aged than in the young, since the hazard of fatal complications is so much greater.

The upper extremities are injured with about the same frequency in pedestrians and in occupants of automobiles (10–15%). Drivers have a slightly higher incidence of these injuries than passengers, as they are often aware of the imminence of a collision and brace themselves with their arms before impact.

Human Factors in Traffic Accidents

A. Role of Alcohol in Traffic Fatalities.

No one who investigates accidental deaths can fail to be impressed by the importance of alcohol as a contributory cause of traffic accidents but alcohol plays an additional role in traffic fatalities. In reports dealing with traffic accidents it is seldom mentioned that alcoholic intoxication greatly complicates the emergency management of an injured person and that even if given the best of treatment his ability to survive

extensive trauma is impaired. An obnoxious, hostile, drunken patient is difficult to examine or control at the accident scene. His perception of pain is impaired and he can give no clear account of the symptoms he does experience. It may be impossible to perform an adequate neurological examination or to determine whether impairments that are found are the result of intoxication or of trauma. Aspiration of vomitus may occur with obstruction of the airway and increased danger of subsequent pneumonitis. The central depression associated with high blood levels of alcohol slows respiration, increases the danger of cerebral and pulmonary edema and complicates the performance of many diagnostic and therapeutic procedures.

Alcoholism may contribute to a traffic fatality just as directly by its effect on the victim's recovery after he is injured as by impairing his judgment and coordination before the accident.

In our series, blood alcohol levels were determined on all traffic victims over 15 years of age who died within 24 hours after the accident. The results provided definite evidence of recent drinking in 55% of fatally injured pedestrians, 60% of automobile drivers and 36% of passengers tested. These findings are similar to those of Freimuth (7) and Gerber (9) (Table VIII).

B. Other Contributing Factors in Traffic Fatalities.

Age, with its associated infirmities of the mind and body, and youth with its heedlessness are important factors in pedestrian accidents. 80% of all pedestrian victims in this series of 121 cases were either under 15 years or over 50 years of age. It is interesting that the age distribution of fatally injured auto occupants was almost exactly the reverse. 79% were found in the ages from 15 to 50.

Defects of hearing, vision and locomotion were present in many of the elderly pedestrians and doubtless played an important role in causing some of the accidents. The general physical condition in many elderly accident victims was such that they could not readily cope with even moderate trauma and the associated shock or extensive therapeutic procedures. Thus the disabilities accompanying old age have an effect on

TABLE VIII

Post-Mortem Blood Alcohol Determinations in Traffic Fatalities

	Cases Tested	Blood Alcohol Level Elevated			Percentage of Victims Who Had Been Drinking
		Negative	Under 0.15%	Over 0.15%	
Present Series—Blood Alcohol [9]					
Pedestrians	(44)	48%	18%	34%	52%
Drivers	(38)	40%	39%	21%	60%
Passengers	(39)	64%	10%	26%	36%
Cyclists	(4)	50%	50%	—	50%
Gonzales (Brain Alcohol) (8)					
Pedestrians	(2,472)	69.3%	12.9%	17.8%	30.7%
Drivers	(214)	43.5%	30.1%	26.4%	56.5%
Passengers	(273)	54.3%	23.8%	21.9%	45.7%
Cyclists	(36)	83.4%	8.3%	8.3%	16.6%
Freimuth (Blood Alcohol) (7)					
Pedestrians	(207)	56.1%	13%	30.9%	43.9%
Drivers	(156)	41.8%	21%	37.2%	58.2%
Passengers	(137)	57%	16.7%	26.3%	43%
Gerber (Blood Alcohol) (9)					
Pedestrians		54%			46%
Drivers		46%			54%
Passengers		58%			42%

traffic fatalities somewhat comparable to alcoholism in so far as they increase the risk of a person becoming involved in an accident and decrease his chance of surviving the resulting injury.

Cause of Death

The precise cause of death in traffic accidents is impossible to determine without a thorough autopsy. Even with an autopsy it may be difficult to assign death to a single cause. The victim may have few external signs of trauma and yet may have profound internal injuries such as a ruptured aorta or a massive subdural hematoma. In other cases, multiple moderate injuries to several body areas, no one of which alone

[9] Blood alcohol was determined on all victims over 15 years of age who died within 24 hours after the accident.

would be sufficient to cause death, may combine to produce shock or other changes incompatible with life.

The frequency of severe injuries to several body areas deserves emphasis. In many instances three or four separate injuries are found, any one of which could reasonably be considered an adequate cause of death. In our study severe injuries to more than one body area were found in over half of all fatally injured car occupants and pedestrians. In ejected car occupants multiple injuries occurred in 77% and severe injuries to three or more body areas occurred in 27%. In all fatal accidents combined the most frequent sites of serious injuries were the head and chest, either separately, in combination with each other, or with some other body area (Table IX).

TABLE IX

Single and Multiple Sites of Serious Injury

	Auto Occupants [10]		Pedestrians	Cyclists	Auto-Train
	Non-Ejected (117 cases)	Ejected (33 cases)	(121 cases)	(9 cases)	(7 cases)
Head, alone	25	5	26	4	–
Head and neck	4	–	–	–	–
Head and chest	19	7	10	2	–
Head and abdomen	8	–	5	1	–
Head and extremity	–	–	1	–	1
Head and pelvis	1	1	7	1	–
Neck, alone	3	1	2	–	–
Neck and chest	2	–	1	–	–
Chest, alone	12	2	8	–	–
Chest and abdomen	12	4	7	–	1
Chest and pelvis	2	–	4	–	–
Abdomen, alone	7	3	5	–	–
Abdomen and pelvis	–	1	1	1	–
Pelvis, alone	1	–	8	–	–
Pelvis and extremity	–	–	1	–	–
Extremity, alone	7	–	8	–	–
Three or more sites	13	9	21	–	5
Miscellaneous [11]	1	–	6	–	–
Total cases with injuries of single sites	55	11	57	4	–
Injuries at multiple sites	62	22	64	5	7

[10] Only deceleration accidents.

[11] Miscellaneous causes of death—emboli, pneumonia, etc.

In considering the duration of survival after the accident we find that 28% of the pedestrians died on the scene or were dead on arrival at the hospital. Within 24 hours after the accident 60% of all pedestrian deaths had occurred. Among fatally injured auto occupants 38% did not reach the hospital alive and 63% of the deaths took place within 24 hours after the accident.

Summary

Among 302 traffic fatalities, pedestrians accounted for 40%, auto-auto collisions 30%, off-the-roadway accidents 24%, auto-train collisions and cycling accidents 3% each.

In pedestrians the head and extremities were the most frequently injured body areas. They were most frequently injured by primary impact alone but in many instances there were additional crushing or throwing components; or pure crushing trauma.

Occupants of cars involved in both auto-auto accidents or off-the-roadway accidents sustain most of their injuries as a result of deceleration impact. Whiplash injury following rear impact collisions was encountered in a very few instances. The head and chest were the most commonly injured areas in deceleration accidents.

Fatally injured drivers and passengers had about the same distribution of injuries in the various body areas. Ejection definitely increased the severity and multiplicity of injuries. Overturning increased the likelihood that the occupants would be ejected.

The use of safety belts or some similar form of restraint by the car occupants would have significantly decreased the number and severity of the injuries. It would have reduced the risk of ejection, cushioned abrupt deceleration and diminished the force of impact with the steering post, dashboard and other structures. Evaluation of the fatal injuries indicates that safety belts would have been life-saving in many instances.

Autopsy findings in these victims illustrated time and again that a normal external appearance should not mislead either the surgeon or the medical examiner into assuming that the victim does not have serious internal injuries. A far

greater number of preventable deaths resulted from failure to suspect the presence of obscure injuries than from failure to treat recognized injuries properly. Greater familiarity on the part of the physician with the types and common locations of injuries suffered by the victims of traffic accidents and particularly an appreciation of the frequency with which multiple injuries and unsuspected internal injuries occur could lead to better diagnosis and treatment. This in itself would reduce substantially the appalling number of traffic fatalities.

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Post-mortem Biochemical Changes*

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The material presented was obtained to determine what, if any, were the chemical changes occurring in the body after death and if, more specifically, the post-mortem interval could be predicted by a knowledge of the chemical changes. The data are based primarily on a series of chemical examinations done on 20 bodies in which a systematic approach to the problem was made by sampling heart blood at varying intervals following death. Other correlated work of the author will be mentioned when necessary to provide a more adequate appraisal of the problem.

Method

There were 16 adult males and 4 adult females in the study. The ages varied from 25–55 years. The cause of death as established by autopsy was heart disease, coronary arteriosclerosis, and one case of fatal trauma not associated with extensive tissue destruction. In each case, it was reasonably clear that no significant biochemical alteration antedated death. All patients showed normal body build and in all death was sudden and witnessed (or the time of death could be established within a few minutes). Shortly after death, usually within less than one hour (in one instance two hours) the bodies were removed to Suffolk County Mortuary, South-

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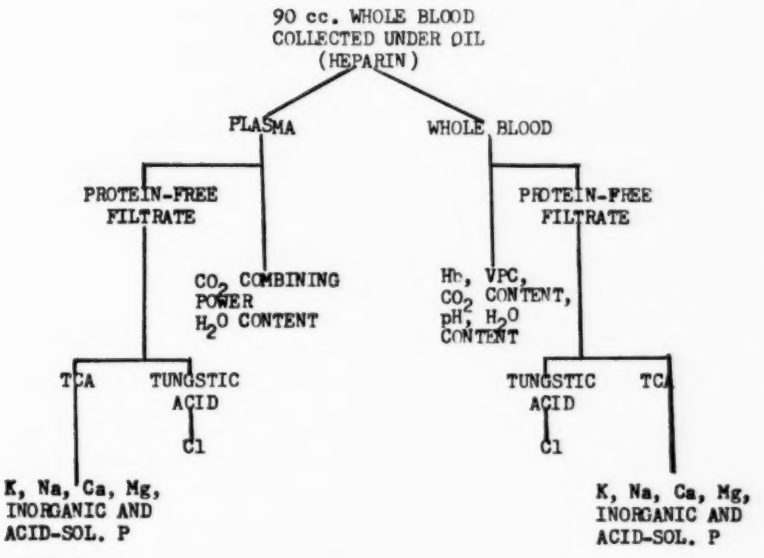
ern District, Boston, Massachusetts,[1] where they were placed in refrigeration (circa 2° C.). The single exception occurred in a woman of 35 who died suddenly while a patient in a state mental hospital. Her body was refrigerated almost immediately after her death from rheumatic heart disease.

At least one and in some instances multiple sampling of heart blood was obtained in all cases up to at least 24 hours after death. Using a large syringe and a large bore needle blood was withdrawn from the right ventricle under oil through the third costal interspace just to the right of the midline. Excessive clotting did not seem to be a factor, generally nothing impeded the flow of the blood into the syringe. To obtain as representative a sample as possible, the blood was drawn in and out of the syringe several times.

Tables 1 and 2 show the system of chemical analysis. Ninety mls. of blood under oil was heparinized and separated

Table 1

SCHEME OF CHEMICAL ANALYSIS

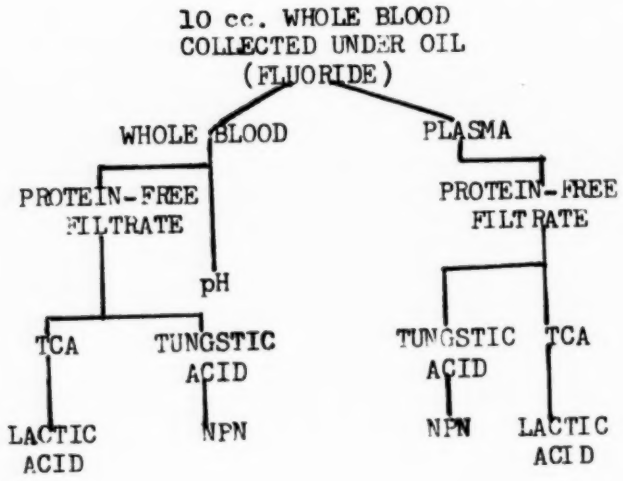


[1] Through the kind cooperation of Dr. Timothy Leary, Medical Examiner, Suffolk County, now deceased.

into whole blood and plasma. From the whole blood hemoglobin, hematocrit, carbon dioxide, pH and water content determinations were made and from a protein-free filtrate of this electrolytes and inorganic and organic acid soluble P was obtained. From the plasma, CO_2 combining power (CO_{2cp}) and water content were obtained. From a protein-free infiltrate of the plasma, electrolytes and inorganic and organic acid soluble P were determined also. An additional 10 mls. of whole blood was preserved by fluoride (Table 2) and determinations of lactic acid and non-protein nitrogen were made on both whole blood and plasma.

Table 2

SCHEME OF CHEMICAL ANALYSIS



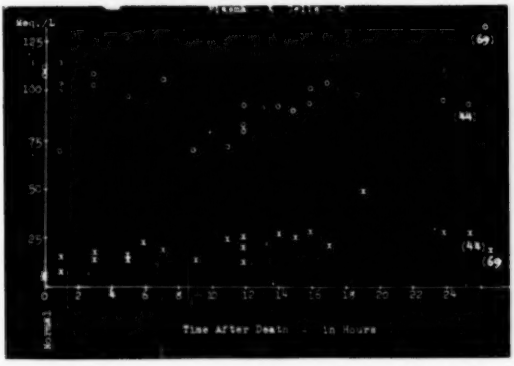
Results

Plasma and erythrocyte values interpolated from plasma and whole blood data were plotted for all cases in relation to the post-mortem time interval, greatest 69 hours. In no instance was hemolysis present. This finding is of fundamental significance, it indicates excellent preservation and

places all cases into what is termed the "early post-mortem period."

Potassium

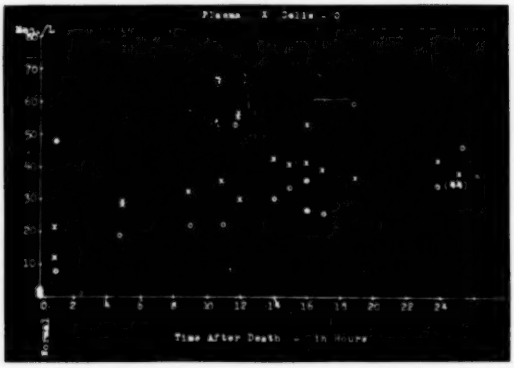
Graph 1 gives the data on the K results. Within one hour after death, the first observation in the post period, there was a significant increase in K values up to 18 mEq/L followed by a further although gradual increase to levels in the vicinity of 25 mEq/L at 12–24 hours. As the K of plasma increased, there appeared to be a decrease in cellular K although not until the second 12 hours, however. One case observed 44 hours and one 69 hours following death were not substantially different than the other values. In the 69 hour case, refrigeration was initiated almost immediately following the sudden and unexpected death. The K value resembled that seen relatively early in the post-mortem material indicating that prompt refrigeration tends to impede post-mortem change.



Graph 1—Potassium content of human heart blood after death.

Lactic Acid

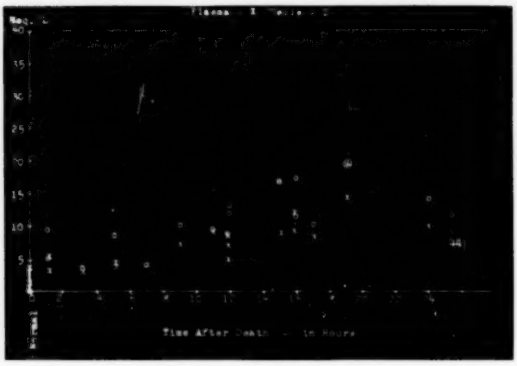
Lactic acid values in the series of 20 cases are shown in Graph 2. Found in very small amounts normally in both plasma and erythrocytes during life (circa 1 mEq/L) the one hour values were prominently increased, circa 20 mEq/L. Following this a progressive still further increase occurred so that in the 12–24 hour period values were 50–75 fold higher than the normal ante-mortem concentration.



Graph 2—Lactic acid of human heart blood after death.

Inorganic and Organic Acid P

Graph 3 shows the results of inorganic P determinations. Normally present in plasma to approximately 2–3 mEq/L while absent in erythrocytes, the one hour values of inorganic P after death show a marked increase in both plasma and erythrocytes. Subsequently in the post-mortem period levels became still higher to values of 20 mEq/L.



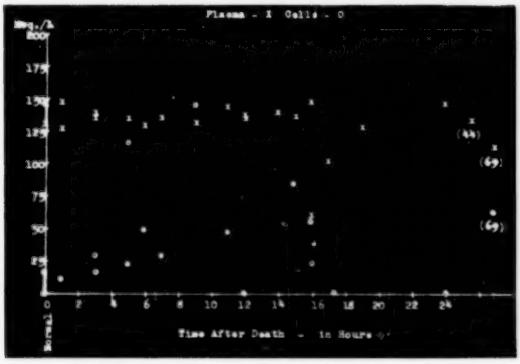
Graph 3—Inorganic phosphorus of human heart blood after death.

The cause for the rise of inorganic P is unclear, the source may be from hydrolysis of organic phosphorus compounds. With regard to the latter, it was observed that organic acid

phosphorus was prominently increased in both plasma and cells. Normally organic acid P compounds are not present in these tissues, the only available source of organic acid P is in tissue cell fluid where it is present to approximately 100 mEq/L. This evidence indicates diffusion of organic acid P from tissue cells to blood in the early post-mortem period.

Sodium

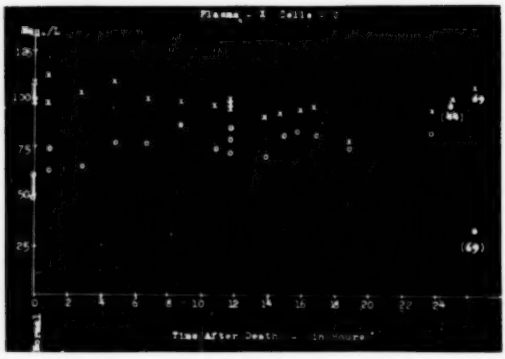
Graph 4 shows the results of Na determinations. It will be seen that plasma Na remained constant until the second 12 hour post-mortem period when a somewhat inconclusive decrease could be observed. Calculated values for sodium content of erythrocytes indicated a progressive increase in Na implying diffusion of the electrolyte across the damaged cell membrane although not until the second 12 hour period.



Graph 4—Sodium content of human heart blood after death.

Chloride

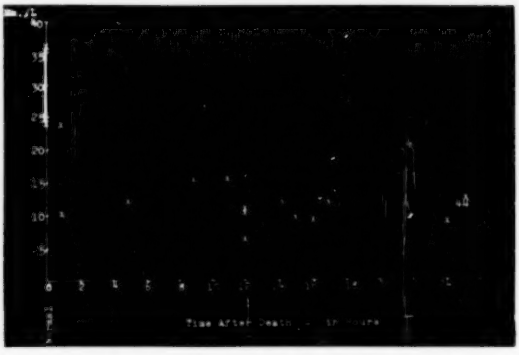
Graph 5 shows the results of Cl determination. Normal values for plasma Cl are in the range of 102 mEq/L whereas in erythrocytes it is about half this figure. It will be seen that gradual although incomplete equilibrium took place, plasma Cl being decreased as erythrocyte Cl increased, thus, the average plasma Cl value 24 hours after death in this series was in the range of 80–90 mEq/L.



Graph 5—Chloride content of human heart blood after death.

Plasma CO_2 Combining Power (CO_{2cp}), pH and CO_2

The normal value for plasma CO_{2cp} varies from 25–35 mM/L. Graph 6 indicates a regular post-mortem decrease in these values to 10–20 mM/L. The probable explanation may be the marked post-mortem production of lactic acid with consequent immobilization of base as Na lactate. A series of examinations done subsequent to the series on CO_{2cp} showed plasma CO_2 content to be unchanged during the post-mortem interval (although it is of course substantially increased in the agonal period). Actually, the values obtained for plasma CO_2 were incompatible with simple solution, to account for

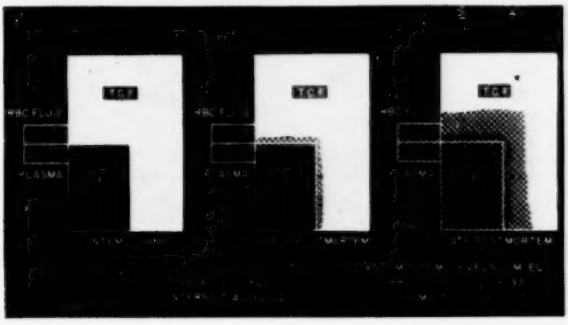


Graph 6—Plasma carbon dioxide combining power of human heart blood after death.

them the presence of carbon dioxide under increased pressure ("supersaturation") needed to be postulated. pH values are not shown graphically and averaged pH 6.73 for the first 12 hour period and 6.43 for the second.

Magnesium

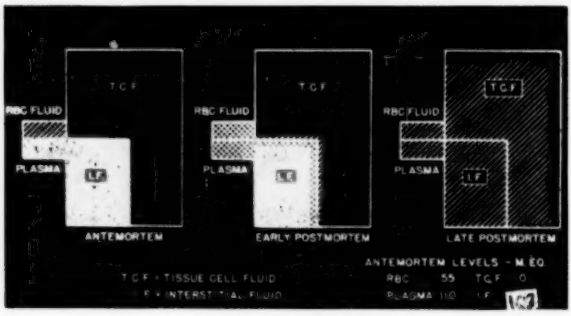
Mg values were not substantially increased during the post-mortem period in which these cases were observed. Graph 7 shows a semidiagrammatic concept of post-mortem changes over a wider interval to include early and late changes. In erythrocyte, plasma and interstitial fluid ante-mortem Mg content averages 2–4 mEq/L. Mg is substantially higher in tissue cell fluid, approximately 43 mEq/L. During the early post-mortem period such as was observed in our series of 20 cases, tissue cell integrity to Mg seemed to be maintained, there is little if any variation in plasma or erythrocyte Mg. When post-mortem change becomes prominent (the late post-mortem period) *and hemolysis occurs*, Mg. redistributes, as the graph indicates so that eventual plasma Mg values are in the range of 20–30 mEq/L. Inferentially, there is of course, a concomitant decrease in tissue Mg. Knowledge of this post-mortem artefact is of value in the diagnosis of death by drowning in sea water. Whereas a concentration of 20–30 mEq/L. Mg in left heart blood would be diagnostic of death by drowning in sea water in the early post-mortem period, such would not be the case after the onset of decomposition.



Graph 7—Changes in magnesium content of body fluids after death.

Chloride Changes in Early and Late Post-mortem Period

A change occurs in Cl redistribution somewhat analogous to although the reverse of Mg. (Graph 8). In the ante-mortem state, plasma and interstitial fluid Cl are high (circa 102 mEq/L), whereas erythrocyte Cl is half of this (55 mEq/L). Tissue cells contain no Cl. In the early post-mortem period, simple redistribution between plasma and erythrocyte CL (see Graph 5) occurs, thus the plasma level (and erythrocyte fluid) may ultimately approximate 80–90 mEq/L. Later in the post-mortem interval after hemolysis has occurred, Cl redistributes still further, tissue cell fluid takes up Cl and the value of plasma Cl decreases to an ultimate low of nearly 55 mEq/L. These observations have practical interest. Given a body found dead in fresh water *early* in the post-mortem period, a plasma Cl of 55 mEq/L in the left heart blood would be considered consistent with death by drowning in fresh water. The same situation obviously would not be the case if the post-mortem period were more advanced and early decomposition had been instituted. Obviously there are other factors involved in the chemical diagnosis of death by drowning, the disproportion in Cl (and Mg) in left and right heart blood, etc. (1).



Graph 8—Changes in chloride content of body fluids after death.

Discussion

An analysis of the results should include answers to the questions, when and how do these striking biochemical alterations come about? The fact that my earliest observations

showed marked variation from normal ante-mortem figures, sometimes in as little as one hour after death, means quite probably that the agonal period was involved. In every agonal period CO_2 accumulates, in my own personal experience O_2 invariably disappears (2). In fatal asphyxia a variety of changes occur, they include increases in plasma K, inorganic P, lactic acid, and so on, exactly similar to those encountered in this series. Therefore, the evidence is strong that terminal anoxia participates prominently in the early changes noted.

This is not to say that there were no post-mortem alterations. From the 1–2 hour mark to the 12 hour mark lactic acid and inorganic P increased further indicating aneorobic chemical reactions, plasma K increased, cell sodium decreased and organic acid P appeared where it naturally is absent; these changes presumably reflected increasing permeability of cell membranes. Secondary to lactic acid production which increases prominently in post-mortem tissues some fifty-fold is the decrease in pH and plasma CO_{2cp}. As pointed out the latter effect appears to be due to immobilization of base, and is in a sense an artefact, if by this one postulates ante-mortem acidosis, plasma CO_2 remains constant.

Later within the post-mortem period, specifically the 12–24 hour period, a further change occurs consisting of a diffusion of Cl between erythrocytes and plasma to a plasma level circa 85 mEq/L. Complete Cl redistribution does not occur until later when decomposition is present.[2]

A shift of electrolytes not occurring until the late post-mortem interval and not actually measured in this series includes changes in Mg and Cl. In the case of Mg, hemolyzed blood contains Mg in large amounts to the extent of 20–30 mEq/L or more, the only possible source is tissue cell Mg. Similarly Cl in hemolyzed blood decreases to approximately 55 mEq/L from a normal of plasma 102 mEq/L and early equilibrium plasma values of 85 mEq/L. This clearly must indicate diffusion into tissue cell and interstitial fluid.

[2] As mentioned, this work was done completely in the early post-mortem period. In no instance was hemolysis in heart blood present. In an attempt to secure a definitive measure, the absence or presence of hemolysis is suggested as a criterion for identifying the post-mortem stage characterizing it into early and late.

Knowledge of these changes is obviously important in the diagnosis of death by drowning in fresh and sea water.

Calcium is absent in tissue cells and erythrocytes but present in both interstitial fluid and plasma. In these observations, calcium remained constant in plasma during the early post-mortem period, thus, the presence of a low plasma Ca is significant in the absence of hemolysis.

No data on glucose was obtained in this series because blood was taken from the right side of the heart. It is well established that right heart blood glucose rises unpredictably due to post-mortem hepatic glycogenolysis. To correctly assess glucose levels at time of death, blood from the left heart needs to be collected. A correction for the post-mortem time interval then needs to be made since glucose decreases at the rate of approximately 6–10 mg % per hour in the intact body. It should be appreciated in fatal asphyxia that elevations to 500–600 mg % may occur; it is not at all unusual in the average non-asphyxial death for terminal glucose levels to reach 200 mg %. Thus, the significance of any post-mortem glucose determination must be made with appreciation of the artefacts involved.

In a similar concept alcohol needs to be determined in left heart rather than in right heart blood or in a mixture from both sides of the heart, a point of less importance than in the case of glucose, however. Alcohol continues to be metabolized in the liver for some time following death. In several instances I have seen progressive decrease in ethyl alcohol content of right heart blood as the post-mortem interval increased, the left heart alcohol remaining constant during this period of observation.

Summary

Post-mortem biochemical changes occur as a result of the agonal period of anoxia, the continuation of biochemical changes in the early post-mortem period and the distribution of easily diffusible substances between erythrocytes and plasma as well as between interstitial fluid, tissue cells and the blood.

The agonal changes are, as measured in plasma, an increase in K, lactic acid, inorganic P, glucose (as measured in left heart blood), CO_2, and a decrease in pH.

The early post-mortem interval is described as that period extending to the onset of hemolysis. The bulk of the material presented in this paper deals with this early post-mortem period. During it there is a further increase in plasma K, lactic acid, and inorganic P while organic acid P appears for the first time in erythrocytes and plasma. Plasma values decrease for CO_{2cp}, Cl, glucose, and pH. The CO_2 content remains unchanged after death and the heart blood remains O_2 free. Ca remains constant.

Relatively late in the post-mortem period, as measured by the presence of hemolysis and judged grossly by early decomposition redistribution occurs as shown by plasma Mg increase, Ca decrease, and a further decrease in Cl.

By the usual non-specific methods measuring volatile reducing capacity, reliable results for ethyl alcohol during but not after the early post-mortem period can be obtained if blood is sampled from the left heart.

Hyperglycemia is a non-specific manifestation of the agonal period of anoxia. Analysis should be done in left heart blood. Glucose decreases circa 6–10 mg %/hr. in the intact body.

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American Criminalistics Abroad*

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Why should the United States be interested in assisting in the development of foreign police departments? Such assistance is a facet of public administration efforts in foreign countries and it has expanded, because countries realize the need for an effective police department to provide an atmosphere that facilitates economic development, since this cannot exist without law and order. By increasing the effectiveness of the police departments in the country, a higher level of law and order is created and social and economic progress can take place in an orderly manner.

Assistance to the police of a particular country will vary according to particular needs as set forth in mutually agreed programs. One of the oldest public safety technical cooperation programs of the ICA is in Indonesia where there is one police department providing police service for the entire country and numbers approximately 110,000 men. Indonesia is a country of islands and about 85 million people and extends over an area as broad as the United States with about one quarter the land mass.

The population of Indonesia is a combination of the oriental and polynesian. They are generally slight of build, light brown skin, brown eyes and black hair. By far the greater percentage of the population are farmers. The country suffers, in its attempts to become an economically sound, independent nation, from a lack of skilled technicians.

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The Indonesian Government requested assistance from the United States to further improve their police organization. Subsequently, a Public Safety Division of the ICA Mission in Indonesia was staffed with specialists in telecommunications, police administration, sea and air police development, training, automotive maintenance, logistics and criminalistics. Each specialist is responsible for providing technical cooperation in his functional field at all echelons of the police organization.

Each advisor works with an assigned official called his "counterpart." It is with this officer that technical cooperation takes place. In short, the American technician serves as an advisor in the development of a modern and effective police organization.

My principal responsibility was advising in the development of crime laboratory facilities for the Indonesian National Police. Basically, the problem was one of planning for laboratory space, equipment, and training personnel in terms of anticipated need. At the onset the average police investigator was not fully aware of the role of criminalistics in criminal investigation. Only a few investigators possessed a technical background. This necessitated long-range training plans to provide properly oriented police investigators.

Upon my arrival in Indonesia in September of 1955, I found space had been provided for a crime laboratory in the newly-constructed police headquarters building at Djakarta. Several microscopes and some camera equipment were on hand. No skilled technicians were available.

To advise the establishment of a crime laboratory service for the Indonesian National Police, I first made a comprehensive survey. A study was made of reported offenses. Attention was given to selected offenses such as homicides, burglaries, arsons, felonies involving automobiles, and sex offenses which were considered most likely to produce evidence of potential value for laboratory examination. An estimate of potential laboratory case load was then based on the above crime rate which was found to be about 10 per cent of the total number of offenses. This study was coupled with a

survey of the personnel training level and competency in the various provinces and routes for shipping evidence was determined. Based on this survey, it was decided to have one laboratory established at Djakarta, in western Java, and a second at Surabaja, in eastern Java. Each laboratory was planned to be of nearly the same capability and to serve the western and eastern halves of the country.

In considering laboratory space requirements, it was determined that separate sections were desirable for questioned documents, firearms identification and toolmarks, chemistry, microanalysis, photography, special instruments (spectrography, x-ray diffraction) and shop, evidence storage and administrative spaces. A new laboratory building was designed for the branch laboratory at Surabaja. Special equipment (water trap for projectile recovery) and furniture were designed for each laboratory.

Whenever possible, materials and equipment available locally were used. It must be remembered that there is practically no industry in Indonesia to provide any of the technical and expendable commodities necessary for the laboratory's operation. Consequently, basic laboratory equipment consisting of glassware, chemicals, microscopes, and miscellaneous equipment were provided by ICA for demonstration and instructional purposes.

Advanced training in the United States was provided officers in questioned documents, firearms identification, photography, microanalysis, and police administration. With laboratory equipment available, it was then possible to engage in "on-the-job" training. For example, in several homicide cases in Djakarta, I accompanied laboratory personnel to the crime scene. The evidence collected provided means for demonstration of recommended examination methods in the laboratory, the preparation of exhibits, report writing and ultimately court testimony. During the time I was there, it was not possible to locate officers with sufficient technical background in chemistry and physics to train a chemist and a special instruments analyst. (The search for officers having the necessary technical background is being continued with a possible alternative of hiring civilian personnel.) Complicated

equipment, such as a spectrograph and x-ray diffraction equipment, was not recommended for the laboratory until such time as there is assurance that there will be competent personnel for its operation.

Training was given in the police college concerning the use of the crime laboratory in criminal investigations, including the processing of crime scenes. This course was taught as it might be in this country; i. e., short quizzes, term papers, field problems, critiques, and a written final examination. This was in contrast to the European system to which the students were accustomed wherein lectures and demonstrations were given and each student examined orally at the end of the course. As a result, the students were accustomed to studying only at the end of the year. Giving the course as I did provided a showcase for American teaching methods, yet resulted in many complaints from the students in the first class. About 15 per cent of the students failed and were required to repeat the course; under their previous system of education they could repeat the final examination until they passed the course. The second, third and fourth classes "got the word." They attended class, studied, and claimed it was one of their best and most practical courses.

It is obvious that a fully functioning crime laboratory cannot be established in the period of two years. However, in this time the initial phases were accomplished and the impetus for further development by Indonesian police officers was provided. In this sense, then, it is evident that technical cooperation "works" and meets the needs of both the United States and the host country.

It will remain to be seen whether or not the crime laboratory of the National Police will develop into the technically competent organization that it must be to provide the necessary assistance to the police of Indonesia. At the present time, another American police advisor is in Indonesia to assist in the further development of the laboratories.

The interest of several other countries in the ICA Technical Cooperation Program in Public Safety has been expressed recently. The program, therefore, is slowly expanding. Several of them have requested assistance in the field of crimi-

nalistics. It can be seen that the demand for American know-how in criminalistics is increasing—to the consequent benefit of the United States and countries of the free world.

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The Need for Accurate Findings and Effective Testimony as a Basis for Progressive Appellate Decisions*

*Ordway Hilton, M.A.,** New York, N. Y.*

The forensic scientist has two goals: first, the development and improvement of examination techniques in order that he may reach the correct conclusion in all problems, and second, the complete acceptance of this evidence by both trial and appellate courts. These two goals are interrelated. It may seem strange considering modern court procedure to be at all concerned about progressive appellate decisions and for that matter even to discuss the possibility that a trial court might not hear expert testimony. Nevertheless, some jurisdictions are still saddled with reactionary, ancient, nonprogressive rulings. There is the occasional lower court which excludes certain phases, or the entirety, of expert testimony. What may be more common is for it to hear the testimony, but to brush it aside in the opinion. The newer, less established fields naturally suffer more frequent rebuffs, but such well-established techniques as questioned document examination are not immune to a legal snub. Should we not, therefore, look at the reasons why this action may be taken in order to see what might be done to correct it?

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The basic way in which a new development in forensic science can be accepted by trial courts is for some courageous judge to admit the testimony into evidence and upon appeal to be sustained in his action by an appellate court. At times the acceptance comes about by a slightly different means. The trial court following earlier precedents excludes the evidence, and an appellate court decides upon review that this action was erroneous and remands the case for retrial. The question arises as to when and under what circumstances can we expect such action in connection with any new development in our work?

One of the best statements of when a new scientific principle should be accepted was set forth in the case of Frye v. U. S. (293 Fed. 1013, D. C., 1923) as the court excluded lie detection testimony. The court stated: "Just when a scientific principle or discovery crosses the line between experimental and demonstrable stages is difficult to define. Somewhere in this twilight zone the evidential force of the principle must be recognized, and while the courts will go a long way in admitting expert testimony deduced from a well-recognized scientific principle or discovery, the thing from which the deduction is made must be sufficiently established to have gained general acceptance in the particular field in which it belongs." It is quite obvious that in addition to this criterion the appellate court in sustaining a trial court's admission of scientific evidence must be convinced that the findings are accurate and dependable.

An appellate judge, and for that matter a trial judge, is bound to be influenced in his decisions on scientific evidence by his earlier experiences with expert testimony. In a recent article in the New York Times Magazine (December 1957, p. 51) Anthony Lewis in writing on "How the Supreme Court Reaches Decisions" had this to say about the process by which a judge makes up his mind in reviewing a case. "It must be recognized that a large part of the process has taken place long before the case ever arose. For the way a justice of the Supreme Court reacts to a case depends, inevitably, to a large degree on the view of life and society that he has built up in a lifetime." Translating this to our own problem we

can certainly expect any judge to look back on his days as a trial attorney and to depend in some measure on his former experiences with expert witnesses. If he enjoyed high quality work and effective presentation of findings, he is naturally going to look more favorably upon new ideas than if he has been used to indifferent work, "paid testimony," and findings which for the most part depended upon knowledge of what he would like them to be.

To assure continuous, progressive appellate decisions over a course of years we as a group must strive constantly to improve the quality of technical work and the effectiveness of our presentation in court. Each case, large or small, important or rather insignificant, is a further opportunity to enlighten the legal profession on the full value of expert testimony. However, if this testimony deteriorates into frequent courtroom battles between two or three pseudo experts, as unfortunately in some areas it may from time to time, we can expect to find an entire generation of lawyers and judges listening to this evidence with skepticism and disbelief. May we not anticipate a reflection of such disbelief in trial and appellate decisions?

Sometimes knowing the quality of work that is being done in a particular area we can begin to understand why legal decisions are not as receptive to our testimony as we would like. Sometimes it is amazing how good the decisions are despite the usual expert testimony. On the other hand, for example, when one looks at the work of certain pioneers and leading experts in the field of questioned documents in particular eastern and western states he can begin to understand better why these states have come to accept expert testimony so willingly. It would seem probable, therefore, that each of us has his share of responsibility for the way testimony in his field is to be treated in the future if not in some measure today.

Summary

1. There is a correlation between good presentation and good decisions.

2. Judges are influenced by their earlier legal experience in deciding questions involving expert testimony.

3. Constantly good expert work—examination and presentation—assures continuously progressive decisions.
4. Poor expert work in time will bring about reactionary decisions.

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Application of Blood Grouping Tests in Cases of Disputed Maternity*

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The medicolegal application of blood grouping tests has become common-place in problems of disputed paternity, as in proceedings involving babies born out of wedlock, and in divorce and annulment actions (1, 2, 3). In such cases, the maternity of the child is unchallenged, and only paternity is in issue. Less commonly, blood grouping tests have been applied to resolve problems of disputed maternity, as in kidnapping cases, in instances where newborn babies have been inadvertently interchanged in hospitals (4), and in immigration cases where an individual seeking admission to this country falsely claims that certain American citizens are his parents (5). The purpose of this report is to describe two cases of kidnapping which recently occurred in New York City, where blood grouping tests were applied successfully, and to calculate the chances of disproving falsely claimed maternity by blood tests.

Case 1:

A newborn baby was kidnapped from the nursery of a hospital in Brooklyn, New York. The kidnapper had slipped unobtrusively into the hospital nursery during a brief inter-

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** From the Serological Laboratory of the Office of the Chief Medical Examiner of New York City.

lude when no nurse was in attendance, and there were no witnesses to provide any clues as to the kidnapper's identity. As a result of an appeal to the public, making use of the newspapers, the radio and television, an anonymous telephone call finally led to the apprehension of a woman who had in her care an infant who appeared to be the missing baby.

The suspected kidnapper was the mother of four children, whose husband had died several years ago. The woman then went to work but was unable to earn enough to provide for the children, who were then sent to a foundling home by the Welfare Department. The woman claimed that the baby found in her possession had recently been born to her at home, but the police contended she had kidnapped the baby in order to induce a man, whom she asserted was the father, to marry her. Physical examination of the suspect failed to reveal any evidence of recent pregnancy. Moreover, foot prints of the baby were said to correspond with foot prints of the missing baby taken at the hospital at the time of birth, while the parents whose baby had been kidnapped claimed to be able to identify the baby by a small birth mark they had noticed on its eyelid.

Since, despite this evidence, the prisoner continued to insist that the baby was her own, blood grouping tests were carried out at the Police Laboratory which showed the suspect to be group B, her boy friend, group O, and the baby group A. The author was telephoned for his opinion and advice, and he pointed out that while these results showed that the prisoner and her boy friend were not both the parents of the baby, the defendant could now change her story and select a different man belonging to group A or group AB, and claim that she had originally been mistaken and that the newly designated man was really the father. Therefore, it was suggested that additional more complete blood grouping tests be carried out.

For the blood grouping tests, the author obtained freshly drawn blood samples from the baby who was again in the nursery at the hospital, and also drew blood samples from the parents of the kidnapped baby. These three blood samples, as well as the two blood samples provided by the Police Department from the suspected kidnapper and her boy friend, were then tested for the A-B-O groups and subgroups, the

M-N types, the Rh-Hr types, and for factors **P**, **K**, and **F**.[1] The results obtained are summarized in Table 1. As can be seen, the blood groups of the baby correspond satisfactorily in conformity with the laws of heredity with the blood groups of the parents of the kidnapped baby. While blood grouping tests cannot be used to prove parentage, only to exclude parentage, these results have some value as circumstantial evidence. More important, the Rh-Hr blood tests show that the prisoner is not the mother of the baby found in her care. The suspect belongs to type Rh_2Rh_2 and the baby to type Rh_1Rh_1 so that there is double proof of non-maternity. Firstly, the suspect is **rh′** negative (type Rh_2) and so cannot be the mother of the baby who is **hr′** negative (type Rh_1Rh_1); secondly, the suspect is **hr″** negative (type Rh_2Rh_2), so that she cannot be the mother of the baby who is **rh″** negative (type Rh_1).

Thus, the results of the blood grouping tests demonstrated the falsity of the prisoner's protestations that the baby was her own, and helped remove any doubt that the baby in her possession was indeed the kidnapped baby.

TABLE 1

Results of Blood Grouping Tests in Kidnapping Case No. 1

Blood of	A-B-O group	M–N type	Rh-Hr type	P type	Kell type	Duffy type
Father	A_1	MN	Rh_1Rh_1	P	k	F
Mother	A_1	MN	Rh_1Rh_1	P	k	f
Baby	A_1	N	Rh_1Rh_1	p	k	f
Suspected kidnapper	B	MN	Rh_2Rh_2	P	k	f
Boy friend of suspected kidnapper	O	MN	Rh_1Rh_1	P	k	F

Case 2:

Shortly after the kidnapping case just described had been solved, a second kidnapping case took place in New York City, involving a 25-day-old Puerto Rican baby. The mother,

[1] In this paper, in conformity with the recommendation of the Committee on Medicolegal Problems of the American Medical Association, symbols for agglutinogens and phenotypes are printed in regular type, symbols for blood factors and their corresponding antibodies in **bold face** type, and symbols for genes and genotypes in *italics*.

who had been searching for a new place to live with her family, was befriended by another woman, who told her of an apartment that was available in the Bronx. The woman offered to baby-sit while the mother went to look at the apartment. However, the apartment proved to be non-existent, and when the mother returned home, she found that the woman had left taking the baby with her.

The parents broadcast an appeal over radio, television, and in the newspapers, and within a few days, a telephone tip led to the apprehension of the kidnapper in whose custody the baby was found. In this case, identification of the baby was no great problem, and the kidnapper was readily identified by the mother as the woman who had offered to baby-sit, and who had sent her on the wild goose chase for the apartment. Nevertheless, the prisoner, who had three children of her own, insisted that the baby belonged to her and her common-law husband.

Blood specimens were drawn from the two parents, from the baby, and from the kidnapper and her husband at a local hospital where they were tested in the blood bank. The results of the tests were submitted to the police without an interpretation, as given in Table 2, and this report was brought to the author whose help was solicited in evaluating the findings. From an examination of the report rendered by the hospital blood bank, it was immediately apparent that the individual who had carried out the blood tests was not an expert qualified to perform or interpret medicolegal blood grouping tests. First of all, the results of the Rh-Hr tests were reported in protocol form as positive and negative reactions with the various antiserums, and no attempt was made to integrate or interpret the findings by using the appropriate phenotype symbols. Moreover, the headings of the columns, e. g., anti-**rh′** (C), corresponded to the method of labelling Rh-Hr antiserums as required by the Biologics Control Laboratory of the National Institutes of Health, suggesting that the knowledge and experience of the worker was limited to that of a laboratory technician, namely, to the capacity to read labels and to follow the directions as outlined in the literature accompanying each vial of antiserum purchased. That these suspicions were correct was established beyond doubt by the fact that the blood of the kidnapper's common-law husband

was reported to be both **rh'** negative and **hr'** negative, yet the pathologist who signed the report did not consider this odd or worthy of comment. In addition the report gave evidence of lack of qualifications as an expert in that it was incomplete in not including the important M-N tests. Therefore, it was necessary to repeat the entire examination. For this purpose, the original blood specimens were still available, and the results of the new tests carried out by the writer are given in Table 3.

TABLE 2

Report of Blood Grouping Tests in Case 2 Rendered to the Police by Hospital Blood Bank

Blood of	Major type	Rh	rh' (C)	rh'' (E)	hr' (c)
Father (J. T.)	O	Neg.	Neg.	Neg.	Pos.
Mother (D. T.)	O	Pos.	Pos.	Neg.	Pos.
Baby (J. T.)	O	Pos.	Pos.	Neg.	Pos.
Kidnapper	B	Pos.	Neg.	Neg.	Pos.
Kidnapper's husband	O	Pos.	Neg.	Pos.	Neg.

TABLE 3

Results of Blood Grouping Tests in Kidnapping Case No. 2

Blood of	A-B-O group	M–N type	Rh-Hr type	P	Kell type	Duffy type
Father	O	MN	rh'rh	P	k	f
Mother	O	MN	Rh_1rh	P	k	f
Baby	O	M	Rh_1rh	P	k	f
Suspected kidnapper	A_2B	M	Rh_0	p	k	F
Husband of kidnapper	O	MN	Rh_1Rh_2	P	k	f

Comparison of the results given in Tables 2 and 3, shows that in the incomplete tests carried out at the hospital blood bank, there were four errors involving three of the specimens, so that only two of the five individuals had been correctly typed in the original tests. The most blatant error was made in testing the blood of the kidnapper who was reported to be group B instead of group AB. This was a crucial error, because the fact that the kidnapper is group AB while the baby is group O proves that the baby is not hers. All the

other tests, for Rh-Hr, M-N, P, etc. yielded inconclusive results, so that by making the mistake in A-B-O blood grouping, the technician at the hospital blood bank missed the only chance of obtaining a significant result. The kidnapper belonged to subgroup A_2B, and the weak reactions of her red cells with anti-**A** serum account for the error in grouping her blood; possibly, the presence of an anti-$\mathbf{A_1}$ agglutinin in the kidnapper's serum was a further source of confusion to the technician—that is, assuming that the technician tested the serum for its isoagglutinin content.

Chances of Solving Problems of Identity, and of Parentage

As has been pointed out, blood tests are useful in a wide variety of medicolegal problems. In such cases, the tests have value only as negative evidence, i. e., to prove that a certain blood stain does not contain the blood of a given individual, or to prove that a certain individual is not the parent of a given child, etc. The reason why blood tests cannot be used as positive proof of identity or parentage is that the number of known groups is limited, so that the possibility of coincidence is always present.

It is of interest to know what percentage of cases can be solved by blood tests when a person falsely claims or is accused of parentage, or where an imposter claims to be a certain individual whose blood group is known. These chances are not the same for all populations but vary according to the distribution of the blood groups. For example, among certain American Indian tribes where all individuals are group O, A-B-O tests are useless in problems of disputed identity or parentage. In previous papers general formulae for calculating the chances of disproving false claims of identity and parentage were derived (6, 7, 8, 9) but it is not intended to repeat the calculations here, since many of the formulae are very complex, especially those involving the Rh-Hr types. Instead, the numerical results of these calculations have been collected, and the figures are presented in Table 4.

As can be seen, fully 97 percent of problems of falsely claimed identity can be resolved by blood grouping tests, as where an imposter pretends to be a long lost individual of whose blood groups reliable records are available, or where

TABLE 4

Usefulness of Blood Grouping Tests for Disproving Falsely Claimed Identity and Parentage

Problem	Types of cases	Individuals available for testing	Approximate chances of exclusion [2] (percent)			
			Four A-B-O groups	Three M-N types	Eighteen [3] Rh-Hr types	A-B-O, M-N, and Rh-Hr combined
Identity	Criminal identification, imposters, blood stains	Single individuals	64	62	78	97
Maternity	Kidnapping cases, inheritance cases, immigration cases	Putative mother and child	4	12	15	26
Paternity	Disputed paternity, divorce and annulment actions	Putative father, mother and child	18	18	25	50
Parentage	Kidnapping cases, inheritance cases, immigration cases	Putative father, putative mother, and child	28 [4]	28	40 [4]	69
Interchange of infants	Hospital mix-ups	2 pairs of parents and 2 babies	43 [4]	42	55 [4]	85

[2] Assuming distribution of blood groups similar to that of New York City whites.

[3] Some of these types are rare, namely, those involving carriers of genes r', r'', r^y, and R^z. Such rare types contribute little to medicolegal usefulness of the tests.

[4] The figures indicated by the superior figure 4 have been estimated only; all other values were calculated with the aid of formulae from the frequencies of the blood group types and genes in the population.

a person accused of homicide asserts that fresh blood stains on his clothes, which are still wet and can be fully grouped, are his own blood rather than the blood of the deceased. This takes into account only tests with serums anti-**A** and anti-**B** (for the A-B-O groups), anti-**M** and anti-**N** (for the M-N types) and anti-**Rh$_o$**, anti-**rh′**, anti-**rh″**, anti-**hr′** and anti-**hr″** (for the Rh-Hr types). If tests are also carried out with anti-**A$_1$** (for subgroups of A and AB), anti-**S** and anti-**s** (of the M-N-S types), anti-**rh^w**, anti-**hr**, and anti-**rh$_i$** (of the Rh-Hr types), anti-**K** and anti-**k** (of the Kell types), anti-**P**, anti-**F**, anti-**J**, anti-**Lu**, and tests are also carried out for the secretor and non-secretor types, it is evident that false claims of identity can be disproved in almost every case, bearing in mind, however, that the results of these additional tests are to be accepted only with reservations(10).

In disputed maternity involving a putative mother and child, the chances of resolving the problem are considerably lower, since only about 26 percent of such cases can be solved by tests for A-B-O, M-N, and Rh-Hr (cf. Table 4). We were unusually lucky in the two kidnapping cases, therefore, in succeeding in excluding directly the kidnapper herself, since the a priori chances of excluding the kidnappers in both cases were only about 1 in 16. If, however, we count as a solution not only exclusion of maternity, but also exclusion of paternity of the kidnapper's husband, or exclusion of the couple jointly as parents, then fully 69 percent of such cases can be solved, and the a priori chances of solving two such cases in succession would be about 1 in 2. Here again, the chances of arriving at a solution would be increased by carrying out tests for other blood factors such as **A$_1$**, **S**, **s**, **P**, **K**, **k**, **F**, etc., but the antiserums for testing for these additional blood factors are not readily available. Moreover, the antiserums which are available mostly give reactions of low avidity, and unless great pains are taken with the tests, errors in typing readily occur. In general, therefore, in medicolegal problems, it is best to restrict the examination to the "standard" blood factors, **A**, **B**, **M**, **N**, **Rh$_o$**, **rh′**, **rh″**, **hr′**, and **hr″**. Tests for other blood factors increase the chances of exclusion by only a relatively small percentage, and are not worth the extra expenditure of effort and time, considering the possibility that

errors in classification may occur. Moreover, the limited number of studies on the newer blood factors do not give such tests the medicolegal certainty that the other established blood grouping tests have attained.

One of the most common medicolegal problems in which blood grouping tests are applied are cases of disputed paternity, as where a man accused of the paternity of a child born out of wedlock denies the charge, or where a married man sues for divorce on the grounds of adultery. Approximately 50 percent of false accusations of paternity can be refuted by blood grouping tests, provided that the blood of the mother as well as the putative father is examined. If the mother's blood is not available, then the chances of excluding paternity are the same as those given for disputed maternity, that is, 26 percent or only about half as great. Therefore, it is important in cases of disputed paternity to test the blood of the mother of the child wherever possible. When the mother's blood is not available, it is still worth while to proceed with the examination, and the author has had many such cases in which paternity was excluded based on the tests on the putative father and child alone.

An interesting type of problem, and one fortunately of rare occurrence, is the accidental interchange of infants in a hospital. A classical example occurred in 1930 in Chicago which was solved by the A-B-O tests. (One pair of parents was O $\times$ O, the second O $\times$ AB, and the children O and A respectively.) Since in such cases two pairs of parents and two children are generally available for examination, the chances of arriving at a solution are high—as many as 85 percent of such cases can be solved by tests for A-B-O, M-N, and the Rh-Hr types.

Comment

The field of immunohematology has become exceedingly complex, so that there are physicians who devote their full time to work in this specialty. Only such individuals are qualified to carry out blood tests in medicolegal problems of disputed parentage. The serious errors which occur when poorly qualified persons carry out these examinations were illustrated by the experience in Case 2 of the present report and by cases

previously reported(11), and many other cases that have come to the attention of the author. Recently, the College of American Pathologists has published a booklet containing lists of names of Fellows who have indicated their willingness to act as consultants in carrying out certain specialized laboratory examinations. As many as 200 indicated that they were willing to carry out blood grouping tests in disputed parentage cases, but of these self-designated experts less than 5 percent actually specialize in immunohematology and therefore may be considered properly qualified.

Ability to group and match blood for blood transfusions does not qualify one for medicolegal blood grouping tests. The reason for this is that the former entails tests only for factors **A**, **B**, and **Rh**$_o$, and blood bank technicians have no experience with the delicate M-N tests which are so important in medicolegal work. In a recent comparative study of the work of professional blood technicians in three different leading blood laboratories, Osborne (12) found as many as 9 percent discrepancies in the results of the M-N tests. Even more shocking was the experience of the United States Armed Forces during World War II when as many as 10 percent of the A-B-O groups entered on the dog tags proved to be incorrect. A common mistake is to classify group AB blood of subgroup A_2B as group B. In case 2, it was shown how such an error caused the pathologist to miss an opportunity to exclude maternity. About 15 years ago, a similar error led to a false exclusion of paternity, where the putative father was reported to be group B, the mother group O and the baby group A. Actually, as shown by tests carried out by the author, the accused man was group AB (subgroup A_2B), and significantly the baby belonged to subgroup A_2.

Summary

Two kidnapping cases are described in which blood grouping tests proved that the kidnappers' claims of maternity were false. In one case the kidnapper belonged to type Rh_2Rh_2 and the baby to type Rh_1Rh_1, while in the second the kidnapper belonged to group AB and the baby to group O. In the second case, the five blood specimens from the kidnapper and her husband, the two parents, and the baby had first been tested

by a blood bank technician under the direction of a pathologist who classified 3 of the 5 specimens incorrectly. Among these errors, the kidnapper who belonged to subgroup A_2B was incorrectly grouped as B, causing the pathologist to miss the exclusion of maternity.

A table has been prepared listing the chances of solving medicolegal problems of identification and disputed parentage by tests for A-B-O, M-N, and Rh-Hr. The important and difficult problem of qualification of experts for medicolegal blood grouping is also briefly discussed.

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Pulmonary Fat and Bone Marrow Embolism

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Numerous published articles reporting on the presence of fat emboli in the pulmonary arterial circulation following trauma to bones and soft tissues have shown a wide variation of the numbers of cases in each series in which such emboli were demonstrated, (1–9 inclusive). Vance (1) found fat emboli present in 75% of a series of cases of extremity fractures. In more recent studies of cases sustaining fractures and soft tissue injuries, Denman and Gragg (2) noted 47%, Mallory (8) 67%, Scully (9) 90%, and Wyatt and Khoo (4) 100% of their series showed fat emboli were present. In contrast, reports on the presence of pulmonary bone marrow emboli following bone trauma are few in number. Rappaport et al. (10) discovered only 14 cases previously reported in the literature and added 13 cases or (6%) of their own series of more than 200 cases of trauma investigated in which such emboli were demonstrated. Warren (3) in a series of 100 cases of pulmonary fat embolism reported only 3% showing bone marrow emboli. These 3 cases were included in Rappaport's list of 14 noted above.

These reported variations on the percentage incidence and import of significant amounts of bone marrow and/or fat

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emboli occurring in the pulmonary arterial circulation in cases of death following trauma initiated a study to estimate the presence or absence of such emboli in Vermont medicolegal fatalities autopsied by the Office of the State Pathologist during a period of 18 months from July 1956 to January 1958. This study includes not only those cases in which there was grossly obvious trauma of bone and soft tissues but also those where concealed traumatism might be expected such as in cases of electrocution. Cases of gun shot wounds of the head because of the nature and extent of such injuries, where it was estimated death must have occurred instantaneously have not been included. In addition, an equal number of cases where death resulted from organic disease, various poisonings such as from carbon monoxide, barbiturates, strychnine, phosphorous and alcohol and those by drowning have been likewise studied to act in the capacity of a control series for this survey. A table of the results of these cases of traumatic death is presented as Table No. 1. For the sake of brevity, a table of the control series of cases has not been included but the results of these will be considered briefly in the analysis to follow.

Materials and Methods

In each case blocks of lung tissue including the visceral pleura, one block from each lobe, were fixed in 10% buffered formalin and processed for routine paraffin sections. These were studied for the presence of bone marrow emboli in the pulmonary arterial system, and for evidence of presumptive fat distension, vacuolation of the arterioles, and interalveolar capillaries. Adjacent blocks of lung tissue in each case were similarly fixed in formalin, infiltrated in three changes of a mixture of 8 parts Carbowax® 1000 [1], and 2 parts Carbowax 1540, in an incubator at 50°C, remaining in each mixture of Carbowax for a period of 1–2 hours. They were then embedded in a similar mixture of Carbowax®, chilled rapidly in a refrigerator at —4 ° C and sectioned on a rotary microtome at 8–10 mu. The sections were floated on a bath of a solution

[1] Carbide & Carbon Chemical Corp., New York.

of 0.005% "Tergitol® No. 7" [1] in distilled water to dissolve out the Carbowax®, transferred to clean glass slides, stained with oil-red-0, mounted in "Glychrogel®" [2] and examined for the presence or absence of fat in the pulmonary vascular system.

The employment of this Carbowax technique in a study of this sort was found advantageous in that it favored better preservation of lung architecture and the ability to obtain thinner sections than would have been possible by a freezing technique.

The lung sections from each case which showed bone marrow and/or fat emboli within the pulmonary vascular system were photomicrographed in color to furnish a readily demonstrable record of the results of the survey.

Results

Table 1 lists the type of accident, the known or estimated survival period, the presence or absence of bone marrow and/or fat emboli in the lung sections and the major gross lesions sustained in the accident. In 21 of the cases it was necessary to estimate the survival period. In these, the time of survival was determined by a consideration of several factors including witness reports, time of occurrence of the accident, and type and extent of injuries sustained by the victim. It was determined that a reasonably accurate time of survival could be made in all but 3 of the cases. In the tabulation of the results of the study of the lung sections there has been no attempt to list whether bone marrow emboli were of scanty occurrence or numerous but a roughly quantitative estimation has been made for the presence of fat emboli by indicating 1 + for scanty, 2 + for moderate and 3 + for numerous or excessive. In the listing of the major lesions, fractures are listed as 1 + if present and 0 if absent or not demonstrated. The column labeled "Other" includes the presence of contusions, abrasions, lacerations and burns, separately or in combination.

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[2] Zwemer, Anat. Rec. 57:41, 1933.

TABLE 1

No.	Type of Accident	Survival Period		Lung Sections		Major Lesions	
		Known	Estimated	Bone Marrow	Fat	Fractures	Other
1	Fall from height		Less than 5 min.	0	+	0	+
2	Jet plane crash		Less than 1 min.	0	0	+	+
3	Jet plane crash		Less than 1 min.	0	0	+	+
4	Motor vehicle accident	3½ hours		+	3+	+	+
5	Electrocution	12 hours		+	+	0	+
6	Motor vehicle accident		Less than 5 min.	0	2+	0	+
7	Electrocution		Less than 15 min.	+	2+	+	+
8	Fall from horse		Less than 1 min.	0	0	+	+
9	Electrocution		Less than 10 min.	+	+	0	+
10	Motor vehicle collision		Less than 5 min.	0	+	+	+
11	Motor vehicle collision	3 hours		+	2+	+	+
12	Fall from height		None possible	0	+	+	+
13	Motor vehicle accident	3 days		+	3+	+	+
14	Motor vehicle accident	12 hours		+	2+	+	+
15	Motor vehicle accident		Less than 1 min.	0	0	+	+
16	Motor vehicle collision	2½ days		+	2+	+	+

TABLE 1 (Continued)

No.	Type of Accident	Survival Period		Lung Sections		Major Lesions	
		Known	Estimated	Bone Marrow	Fat	Fractures	Other
17	Motor vehicle collision	3½ days		+	2+	+	+
18	Fall from height	3½ hours		+	3+	+	+
19	Skiing accident		Less than 15 min.	0	+	0	+
20	Motor vehicle accident	2 days		+	2+	+	+
21	Motor vehicle collision	20 min.		+	+	+	+
22	Electrocution		Less than 5 min.	0	+	0	+
23	Plane crash		Less than 5 min.	0	+	+	+
24	Plane crash		Less than 5 min.	0	+	+	+
25	Plane crash		3–5 days	+	2+	+	+
26	Motor vehicle collision	30 min.		+	2+	+	+
27	Motor vehicle collision	35 hours		+	2+	+	+
28	Motor vehicle collision		Less than 5 min.	0	+	+	+
29	Motor vehicle collision	2 hours		+	3+	+	+
30	Motor vehicle collision	17½ hours		+	2+	+	+
31	Motor vehicle collision		Less than 5 min.	0	+	+	+
32	Conflagration	18 hours		0	+	0	+

33	Motor vehicle collision		Less than 5 min.	0	2+	+	+
34	Crushing accident	20 min.		+	2+	+	+
35	Crushing accident	10 min.		+	2+	+	+
36	Motor vehicle collision	1 hour		+	3+	+	+
37	Homicide (beating)		None possible	0	+	0	+
38	Motor vehicle collision		Less than 5 min.	0	+	+	+
39	Drowning		None possible	+	2+	0	+
40	Motor vehicle collision	2 hours		+	3+	+	+
TOTAL 40		19	21	22	36	31	40

In this series of 40 cases, 22 (55%) revealed the presence of unmistakable bone marrow emboli in the pulmonary arterial system, and 36 (90%) revealed the presence of fat emboli. In 21 positive for fat emboli (58.3%) the incidence was of moderate amount (2+) and in 6 (16.6%) the extent of embolization was of sufficient magnitude (3+) to have been considered responsible for the death of the individual. This conclusion in these 6 cases (#4, 13, 18, 29, 36, 40) where fat was excessive was supported by the fact that all were under medical observation in hospitals at the time of death and that death occurred with dramatic suddenness in each while apparently responding well under treatment. If the 4 cases (#2, 3, 8, 15) in which death, judged by the character of injuries sustained, must have been practically instantaneous and in which it was therefore felt an insufficient time of survival occurred for either bone marrow or fat emboli to have been able to reach the pulmonary circulation are eliminated from the percentage calculation, then pulmonary fat emboli were demonstrated in 100% of the cases which showed an appreciable time of survival.

In the control series, which constituted an equivalent number of cases, all but one failed to reveal the presence of fat or bone marrow emboli in the pulmonary vessels. The one case which did show the presence of fat emboli in small quantities was that of a man who collapsed suddenly on the street while in apparent good health and expired in a few minutes. Inquiry elicited a history of rheumatic fever and the autopsy revealed rheumatic cardiac pathology with a calcific mitral and aortic stenosis of marked degree. Further investigation revealed that the decedent, a carpenter by trade, had sustained, several days prior to death, minor injuries following a fall from a ladder. The presence of the minimal fat emboli in the lungs apparently was the result of this fall but these were not considered of sufficient magnitude to have constituted a factor in this fatality.

Discussion

Reports of series or individual cases in the literature demonstrating the presence of pulmonary bone marrow emboli in cases of death following trauma where fractures existed or

were suspected are few in number (10) and the percentage of the occurrence of these emboli varies from 3% to 6% (3, 10). In the series presented here, bone marrow emboli were clearly demonstrated in 22 (55%) of the cases in the series. If the 4 cases (#19, 22, 32, 37) in which it was known no bone trauma could have been present and also the 4 cases (#2, 3, 8, 15) where death must have occurred practically instantaneously are deleted from the series then the percentage for bone marrow emboli demonstrated in the remaining number becomes 68.75%. In 19 (86.3%) of these 22 cases bone fractures containing marrow were found at autopsy while in 3 (13.7%) no fractures were noted. Two of the 3 cases in which no fractures were demonstrated were those of accidental electrocution (#5, 9) while the third (#39) occurred in a case of unwitnessed drowning in an individual who was reported to have been subject to epileptiform seizures and may have received injuries prior to drowning. It is of interest to note that all 5 of the lung sections examined in this case of drowning showed from 2 to 6 emboli of bone marrow in widely separated vessels in each section.

Concerning the incident of pulmonary fat emboli in cases of traumatic death where fractures exist or where death results following electrocution, convulsive seizures, soft tissue trauma, or severe burns, the finding of such emboli in 36 (90%) of the cases of our series compares favorably with the findings in the series reported by Scully (9) and if the 4 cases included here in which death must have been instantaneous are deleted, then the percentage (100%) becomes identical to that reported by Wyatt and Khoo (4).

In the 6 cases of this series (#4, 13, 18, 29, 36, 40) in which death could be attributed to the presence of massive pulmonary fat emboli alone, the known survival period of these victims ranged from 1 hour to 3 days following injury. In the 5 cases with a known survival period of less than 1 hour (#19, 21, 26, 34, 35) fat emboli were demonstrated in all and bone marrow emboli in 4 of them (#21, 26, 34, 35). In 3 of these 5 cases (#26, 34, 35) the fat emboli were present in moderate amounts. In the 10 cases with an estimated survival period of less than 5 minutes, 8 showed fat emboli in small quantity and 2 in moderate amount.

The cases with both known and estimated survival periods, showing the presence of fat emboli in moderate or abundant quantity numbered 21 or 52.5% of the total. This does not conform to the percentage figures in Scully's series (9), where only 19% of the cases studied showed more than a slight degree. However, the difference probably lies in the fact that in our cases all of the victims had suffered numerous contusions as well as fractures while many of his cases were fatalities following single gun shot wounds of the head or chest.

It is our intent, as a routine procedure, to continue processing lung sections for fat determinations on all future cases of death following trauma and to report the findings in a subsequent report.

Summary

A study of 40 cases of death following severe trauma together with an equivalent number of deaths resulting from natural causes, poisoning and drowning, were studied for the presence or absence of pulmonary fat and bone marrow emboli utilizing a Carbowax infiltrating and embedding technique.

Pulmonary fat embolism may be demonstrated in 100% of cases of traumatic death following injury to the soft tissues or skeletal structure provided death did not occur instantaneously following injury.

Death by massive pulmonary fat embolism may be more frequent than heretofore realized where multiple fractures and soft tissue injuries are sustained.

Where fractures or severe stress of marrow containing bones have been demonstrated, or can be presumed to exist, the presence of bone marrow as well as fat emboli in the lungs is of much more frequent occurrence than has heretofore been demonstrated.

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Immunological Test for Semen on Female Genitalia as Evidence of Intercourse*

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Semen contains antigenically active substances. This has been known for a long time (1). However, it has been ascertained only recently (2, 3) that the essential, highly organ— and species—specific antigenic material is present both in the spermatozoa and in the seminal plasma. This is probably due to the fact, that these antigens do not originate from the testes, but from the adnexal organs of the genital tract. Thus the antigen is plentiful in the ejaculate of azoospermic subjects. The complement fixation method provides a convenient and highly sensitive technique for this purpose. With the aid of appropriate immune sera, it permits the demonstration of the antigen in seminal plasma diluted many thousand times or with small numbers of spermatozoa (such as suspensions containing 10^6 spermatozoa per ml.) (2).

The demonstration of semen on or around the female genitalia or on stains on garments has forensic implications, for instance in cases of rape, adultery, or sexual homicide (4). The most important method of such evidence is presently the demonstration of spermatozoa by staining. It seemed to us that the sensitive methods of demonstrating

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seminal antigens by immunological methods may be adaptable for forensic use. No such application has been suggested in the literature available to us, except that Farnum (5) found seminal antigen extractable from paper and cloth. However, no details were given in this report on work done in 1901 with the necessarily crude techniques of that period.

Methods

Complement fixation tests were done by the standard Kolmer technique (6) except that only 2/5 of the volumes of reagents suggested by Kolmer were used. Immune sera against human seminal plasma were produced in rabbits as described previously. Specimens were provided in the form of cotton tipped applicators or (preferably) gauze sponges from patients of the hospital's clinic and the private practice of one of us (L. W.). Identification was by numbers only so that the tests were done without foreknowledge of the nature of the specimens. The swabs were delivered to the laboratory and were soaked over night in 4 ml. of physiological saline solution containing 1/10,000 Thimerosal.[1] The fluid was collected and centrifuged. The clear supernatant fluid was not anticomplementary. The material was titrated in dilution steps of 100%, beginning with a 1/2 dilution. Tests were not considered as positive, if complete inhibition of hemolysis was not seen in a dilution of 1/4. Usually, positive reactions were obtained with higher dilutions, sometimes up to 1/256 and occasionally well beyond this point.

The majority of antisera against seminal plasma are entirely free of antibody against human serum. Some show traces of cross reactivity with serum and an occasional marked one (2). We found that the extracts from vaginal swabs often contain material reactive with anti-human serum antibodies. It is therefore important to ascertain absence of cross-reactivity of the immune sera. As an added precaution, we recommend to include with each test a control of dilutions of human serum, starting with 1/100 dilution, which has to remain negative.

[1] "Merthiolate," received through the courtesy of Eli Lilly & Co.

The admixture of blood to the material under examination may create a technical problem. This is understandable, because erythrocytes do absorb the seminal antigen (2). If mixtures of seminal plasma and whole blood in ratios of 1:10 to 1:1000 were examined, the antigen disappeared from the fluid. However, its presence on the erythrocytes could be demonstrated by adding to the washed erythrocytes antiserum and complement. After incubation, the fixation of the complement could be shown, by centrifuging the mixture and demonstrating the disappearance of the complement from the supernatant fluid by the absence of hemolysis on addition of hemolysin and sheep erythrocytes.

Results

The data are summarized in Table I.

The material collected after artificial insemination serves as the positive control. Seminal antigen is regularly demonstrable after this procedure. In the majority of cases, antigen could be demonstrated for several days after insemination. It may also be present on the vulva.

Antigen was found in about 70% of the vaginal specimens after intercourse. It could be demonstrated up to seven days after the last intercourse. Positive results were also obtained from the vulva. However, the antigen could not be found in all cases even after a few hours. It could not be determined whether this loss was due to manipulations like washing or douching. Possibly, it may have something to do with the amount of vaginal or vulval secretion, coital technique or other extraneous circumstances. The cases where the test was positive on the vagina, but not on the vulva, or vice versa, show that it is advisable to examine both sites and possibly other ones, where deposition of semen is suspected.

It is worthy of note, that a positive test was obtained 1½ days after intercourse with an oligospermic man. This illustrates the potential value of the serological test in cases where the microscopic search for spermatozoa is likely to fail.

The results with vaginal specimens from subjects who denied recent sexual activity serve as controls for the absence of non-specific reactions.

TABLE I

Complement Fixation Tests with Anti-Human Seminal Plasma Serum

Source of Specimen	Interval of Time	Specimens Positive	Specimens Negative
Vagina, after intercourse	5–6 hours	2	1 [2]
	7–12 "	2	2
	13–24 "	2	2
	1–2 days	4 [3]	1
	3–4 "	3	0
	5–7 "	3	1
	uncertain, several days	1	0
Vagina, after artificial insemination	0–1 hour	9	0
	2–3 days	5	2
	5 "	0	1
Vagina, no known intercourse		0	14
Vulva after intercourse	6–7 hours	1	1 [4]
	2–3 days	1	3 [5]
Vulva, after artificial insemination	immediately	1	0
	3 days	1	0
Cervical mucus	18 h., 1½ & 7 days	0	3 [6]
Seminal spot on cloth		3	0

[2] Simultaneous specimen from vulva positive.
[3] Including one involving oligospermic semen.
[4] Simultaneous vaginal specimen positive.
[5] Including one, where simultaneous vaginal specimen was positive.
[6] Simultaneous vaginal specimens positive; spermatozoa found microscopically in cervical mucus.

Cervical mucus appears to be a poor place to look for antigen. Spermatozoa were demonstrated in the cervical mucus in each of the cases examined. This observation is of some biological interest in that it shows that seminal plasma does not penetrate the mucus to any noticeable extent. The spermatozoa that do penetrate evidently are not numerous enough to produce reaction in vitro.

The last row of Table I shows that seminal antigen can be extracted and identified from cloth spotted with semen.

Discussion

Evidence has been presented showing that the presence of semen can be demonstrated on swabs from the vagina and

the vulva, and on cloth containing spots of semen by a highly sensitive and specific immunological procedure. The antigen may be present for several days after intercourse. The longest period for which this test was found positive in the present series was seven days.

It is suggested, that the proposed method will be of value in forensic practice, when evidence of the presence of semen on or in the neighborhood of female genitalia or on articles of clothing or bedding is needed. Obviously a positive test would prove only that such contact has taken place, but would give no information on the person involved nor on the exact time of the action. It would appear, that a negative result does not exclude sexual contact.

The immunological method is not meant to supplant, but rather to supplement the presently available ones for the detection of semen. If strong and specific immune sera are available,[7] no particular technical difficulty is expected for the performance of the tests in a laboratory equipped for and experienced in serological work. In comparison with the presently available methods, the serological method would seem to have the following advantages: (1) Material can be collected by any physician without need for special skill or apparatus. (2) There is no critical interval of time within which evidence has to be obtained and examined. (3) As the antigen is stabile under ordinary conditions, it can be kept and forwarded to a laboratory competent to make the test. (4) The presence of azoospermic or oligospermic ejaculate can be detected as well as that of normal semen.

Summary

A sensitive method for the detection of semen from the female genitalia after intercourse has been described. It is based on the high organ and species specificity of the antigens contained in semen. Its use in forensic medicine is suggested.

[7] As the seminal antigen is a very effective one, there should be no particular difficulty to prepare potent antisera. If the demand arises, there should be no trouble to supply such sera from some central agency or a commercial source. For the moment, the senior author is willing to supply the antisera if this problem should arise.

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Anonymous Communications

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The term "Anonymous Communication" implies information received from an unknown source. This could be in the form of an unsigned handwritten, handprinted or typewritten letter, an unidentified phone call, a telegram from an unknown source or even a spoken word transmitted through a third party.

For the purpose of this paper I should like to limit our discussion to the anonymous *handwritten, handprinted* or *typewritten* letter.

My document experience stems from a period of approximately 17 years with the Government in the FBI Document Laboratory and the VA Document Laboratory. The Government laboratories in which I have worked received a great variety of anonymous letters. Some dealt with personal matters, from mild warnings to serious threats—other letters were in a different vein on an international level. Some were merely "crank" letters—others complaints from psychologically unbalanced individuals. However, all of the letters had two things in common, i. e., in order to convey the message they had to (1) use a writing instrument (pen, pencil, typewriter) and (2) use a document upon which the writing was to be placed—and obviously these are the two main items that draw a Document Analyst (or Handwriting Expert) into the solution of cases involving anonymous letters.

The actual comparison of handwriting or typewriting in an anonymous letter case is not a great deal different from the comparison of questioned and known handwriting or

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typewriting specimens. However, in an anonymous letter case one thing is almost certain—the writer prepared the document under some nervous tension and strain. Many of us have a tendency to perspire when we work under tense conditions. The hands become clammy, thus affecting the way we hold a pen or pencil—or it may affect paper movement by the hand sticking to the paper. A pen or pencil in moist or clammy fingers is generally held in a slightly abnormal way. Extra pressure is applied to keep the writing instrument from slipping, thereby curtailing free writing motion; however, it has been my experience that these surrounding conditions, i. e., nervousness and tenseness, do not necessarily cover up basic handwriting characteristics, and known nonrequest specimens can often be sufficient to positively identify the writer of an anonymous letter.

In my work, cases sometimes stem from neuropsychiatric patients. A patient may have a gripe against an individual or against an administrative policy and drop an anonymous letter (sometimes threatening) to a higher Government official. In one case a total of 76 anonymous letters (handwritten and typewritten) were identified as from a single source over a period of several months. In this case letters were mailed to various Government officials, all in the same agency. The letters all ended up in our laboratory, and at first it appeared that there were many different sources—but gradually a pattern formed—ultimately resulting in locating an individual who had a violent dislike for a certain employee and the writer was attempting to have him fired.

In examining anonymous letters, I have found that the attempt to conceal one's identity is usually rather crude and elementary. Disguise is often attempted but when it is attempted, basic handwriting characteristics can still generally be determined. One of the first elements of disguised writing lies in the formation of the capital letters—and the same holds to be true in anonymous letters. However, after beginning to write, the person gradually swings into his old habits. Another element of disguise, viz., backhand writing, is frequently employed by anonymous letter writers but once again, the disguise is generally poor and basic characteristics are not completely obliterated. Punctuation, spelling and

spacing (marginal, between words and between letters) become very important characteristics. The writing instrument is also significant and the document itself plays a very important part in tracking down an anonymous letter writer. A watermark can be of inestimable value in locating the area from which an anonymous letter originated as well as the postmark, stamp, and Postal Station (numbered) at which the stamp on the envelope was cancelled.

One of the most interesting anonymous letters that I have examined involved a tracing of a typewritten note. The writer first typed the anonymous letter and then laboriously traced it, through carbon paper, using a pencil, onto a second sheet of paper. It was a rather tricky method of concealing handwriting characteristics. However, we were able to indicate what style of type was used on the typewriter, as I recall, through the crossbar and lower loop of the "t", the center of the "w" and the wide loop of the "r". The point that I wish to stress is that there are a few anonymous letter writers who realize there are such things as handwriting characteristics which are used in identifying handwriting and these few individuals will use every means at their disposal to attempt to conceal their identity.

In contrast to the anonymous ransom note, some anonymous letters are written with the opposite motive in mind, i. e., they are written with a view to doing good. One such anonymous letter was received in our office in which the writer stated that he wished to anonymously donate $1,000.00 to the U. S. Government, and he enclosed the $1,000.00 in currency. Perhaps the person who sent it had a guilty conscience.

To return to anonymous letter identification, an extremely important item to consider is the document on which the writing appears. Paper fibre analysis is a fascinating subject and one which, I fear, most of us do not delve into deeply enough. I have spent some time, not as much as I'd like to, in examining the various types of paper fibres. I recall a case involving a telegram in which fibre analysis played an important part in the laboratory examination. In that case I was able to definitely determine that two distinct and separate types of fibers were involved and the questioned document came from a different stock than the known. I have

been experimenting with a "Dust Counter" with considerable success in examining paper fibers.

In some instances the anonymous letter has been torn along an edge—either unconsciously while removing the paper from a tablet—or willfully, by tearing the paper using a ruler or straight-edge, in an effort to make it small.

Other physical characteristics of the paper are also important in tracing an anonymous letter—length, width, thickness, opacity (light passage), ruled lines, if present, i. e., flaws in printing the lines—color, distance between lines, etc., finish (linen, laid, etc.)—surface and body of paper—and quality of the paper.

The identification of the writer of an anonymous letter is extremely interesting. It indicates the result of a challenge properly met through the utilization of scientific principles and knowledge. I trust that continued research in this field will reveal even better methods of solving cases of this nature in the future.

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Book Reviews*

GUIDE TO MEDICAL WRITING. A Practical Manual for Physicians, Dentists, Nurses, Pharmacists. By Henry A. Davidson, M.D., Editor, Journal of the Medical Society of New Jersey. The Ronald Press Company, New York. 338 pages, $5.00.

The book illustrates to the prospective author how to pin down his ideas, how to organize his subject matter, how to put it in readable form, and how to master the mechanics of presentation. The author calls attention to the importance of practiced titles, how to achieve clarity and interest without sacrificing professional standards of accuracy. There is advice on how to arrange pictures and charts, and the importance of punctuation, spelling, grammar, footnotes, and bibliography in the final preparation of the manuscript for the editor or publisher.

The occasional author of scientific articles as well as the seasoned writer will find valuable advice and information in this book.

S. L.

FIELD INTERROGATION, by Allen P. Bristow, Sergeant, Los Angeles Sheriff's Department. Charles C Thomas, 1958, 101 pages, $3.75.

Sergeant Bristow supplies a textbook which should certainly be a valuable aid to an instructor. This is relatively an unexplored field and while the author presents the book as field interrogation in reality he is giving us some excellent instruction in patrol.

The author discusses the handicaps under which the patrolling officer works when attempting to obtain information without effecting an arrest or causing unpleasantness. He possibly could have also touched on the type of interrogation used wherein the subject is in custody and has been taken to the station.

The second section covers recognition of criminal traits dealing—excessively we believe—with the recently discharged convict. The author himself hints at this excess.

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* These book reviews have been prepared by selected authorities in the various fields of the forensic sciences, but do not necessarily represent the opinions of the editorial staff, the American Academy of Forensic Sciences, or the publisher.

The third section—documents of identification, types of licenses, service cards, social security cards, etc.—is an interesting and valuable chapter.

In the fourth section the author gets down to the subject of his book—the interrogation. In this short chapter he gives some suggestions on special techniques for special subjects.

The seventh section is devoted to the field of search. Incorporated in this section is a description of methods and tools used by burglars and other types of criminals. He cautions here again in the proper handling of prisoners. (This seems somewhat of a digression, but it is good stuff and well worth reading.)

The last two sections are devoted to his recommendations in instituting a field interrogation program and, as he points out, such a program must be made attractive to the officers and detectives who will execute its functions before it can be successful.

Perhaps a more apt title for this book would be Police Patrol and Field Interrogation.

All in all, this work is a valuable contribution to police training programs.

John Ascher

Articles to Appear in Forthcoming Issues of the Journal of Forensic Sciences

Perforating Lesions of the Esophagus and Their Relation to Trauma—*Gale E. Wilson, M.D.*

Eye Witness Evidence—*Frances E. Camps*

Agonal Peptic Ulceration in Hypoxia Uremia and Stress—*Jorgen B. Dalgaard, M.D.*

Survey of Paternity Disputes in New York City—*Leon N. Sussman, M.D., and Sidney B. Schatkin, LL.B.*

A Recent Development in Ferro-Magnetic Detection—*Lt. John Ascher, LL.B.*

Technical Section

Book Reviews